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BRUCE NUCLEAR POWER DEVELOPMENT (BNPD) POSTOPERATIONAL AQUATIC STUDIES SUMMARY 1979-1981

Report No 84-47-K

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ABSTRACT

This report summarizes the results of three years of postoperational aquatic study conducted between 1979 and 1981 at the Bruce Nuclear Power Development (BNPD) site. An increase in the rate of organic and inorganic sedimentation during the summer was noted, and was possibly related to construction activity at the Bruce GS 'B' intake site. Vertical thermal stratification persisted later in the year at the 7 m contour of Bruce GS 'A' discharge than at other locations sampled. Water quality conditions reflected the oligotrophic state of Lake Huron. Several changes were noted in the biotic community. The taxonomic composition of attached algae, zooplankton and benthic macroinvertebrates varied between sampling years. The number of common naids, amphipods and the trichopteran *Cheumatopsyche* increased substantially in the 1981 rock cage collections. The relative abundance of adult walleye, channel catfish and round whitefish in gill nets increased, with the former two species being more abundant (15 fish per net in September, 1980, and 33 fish per net in July, 1981, respectively) at the 3 m contour of the Bruce GS 'A' discharge transect than at other shoreline sampling locations.

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To Dr. W.R. Effer
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BRUCE NUCLEAR POWER DEVELOPMENT (BNPD)
POSTOPERATIONAL AQUATIC STUDIES
SUMMARY 1979-1981

W. Carey

1.0 INTRODUCTION

This report constitutes a summary of a three-year post-operational aquatic study conducted at the Bruce Nuclear Power Development (BNPD) site from 1979-1981 at the request of Environmental Studies and Assessments Department of Design and Development Division. The objective of the postoperational program was to describe the physical, chemical and biotic characteristics of the nearshore zone of Lake Huron off BNPD in sufficient detail that, when compared with the preoperational studies conducted from 1973-1975, changes resulting from station operation can be determined.

Studies were also conducted at BNPD during the commissioning years of Bruce GS 'A' (1976-1978). For reasons of completeness and to assist in the assessment of effect, additional biotic data (not sampled in the preoperational phase) were collected, including surveys of marshland macrophytes and rock bass spawning sites, acoustic fish and nesting gull censuses, and phytoplankton and zooplankton along grid transects. An effects report covering all studies conducted between 1973 and 1981 at BNPD will follow this report.

The three-year postoperational study included Bruce Generating Station (GS) 'A', Bruce Heavy Water Plant (BHWP) and Douglas Point Generating Station (GS), which have maximum volume discharges of 170, 34 and 14 m^3/s, respectively. All three stations were operational during the course of the three-year

study, and details of station operational history are contained within this report (Section 4.1.1). Design ΔT values are 11.1C° for Bruce GS 'A' and BHWP, and 11.7C° for Douglas Point GS.

The results of each year of postoperational aquatic study are reported in Ontario Hydro Research Division (OHRD) Report Nos 82-107-K (1979), 82-182-K (1980) and 83-96-K (1981).

2.0 STUDY AREA

The study area was located on the eastern shore of Lake Huron and encompassed a 14-km stretch of shoreline from Sand Bay in the north to Gunn Point in the south (Figure 1). Bruce GS 'A' discharges heated effluent in a northerly direction across the mouth of a large bay, Baie du Doré, while BHWP and Douglas Point GS discharge heated water into the lake in westerly and southwesterly directions, respectively (Figure 1). The shoreline is rather irregular at the BNPD site and features several bays and points. The lakeward limit of the study area was the 12 m depth contour, except for some plankton grid samples obtained farther offshore (Figure 2).

Bruce GS 'B', located at the southern limit of BNPD, was under construction during the 1979-1981 study period but was not included in the BNPD survey since it was the subject of another study. During May to September, 1979, the Bruce GS 'B' discharge dyke was under construction. Excavation of the Bruce GS 'B' intake occurred from May to September, 1981. These construction activities may have had some influence on the flux of fine particulate matter in the BNPD nearshore zone.

Predominantly northerly currents occur in the nearshore zone off BNPD and exceed southerly currents by a factor of 2:1. During 1977 to 1979 mean current speeds ranged between 9.7 and 16.6 cm/s, with the maximum current speed of 51.4 cm/s recorded in 1979 (Ontario Hydro Design and Development Report No 82393). Thus longshore currents capable of influencing the direction of thermal plumes produced within the study area occur more frequently than onshore or offshore currents.

3.0 METHODS

Complete descriptions of sampling methods, locations and schedules are contained in the individual reports for each year of study (OHRD Report Nos 82-107-K, 82-182-K and 83-96-K). Sampling methodology was consistent over the three years of study, which included one year of intensive sampling (1979) and two years of less intensive sampling (1980 and 1981).

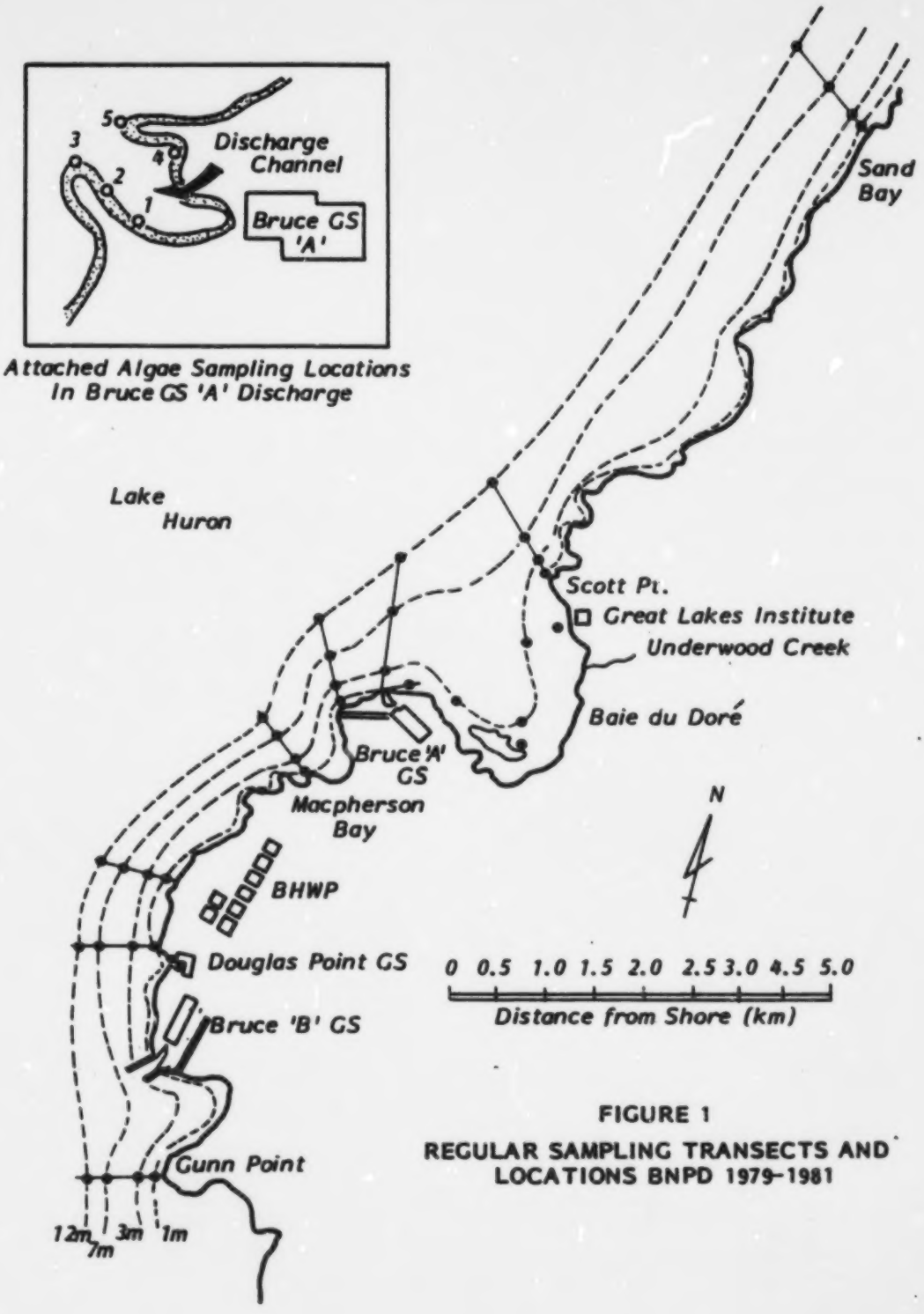

FIGURE 1

REGULAR SAMPLING TRANSECTS AND LOCATIONS BNPD 1979-1981

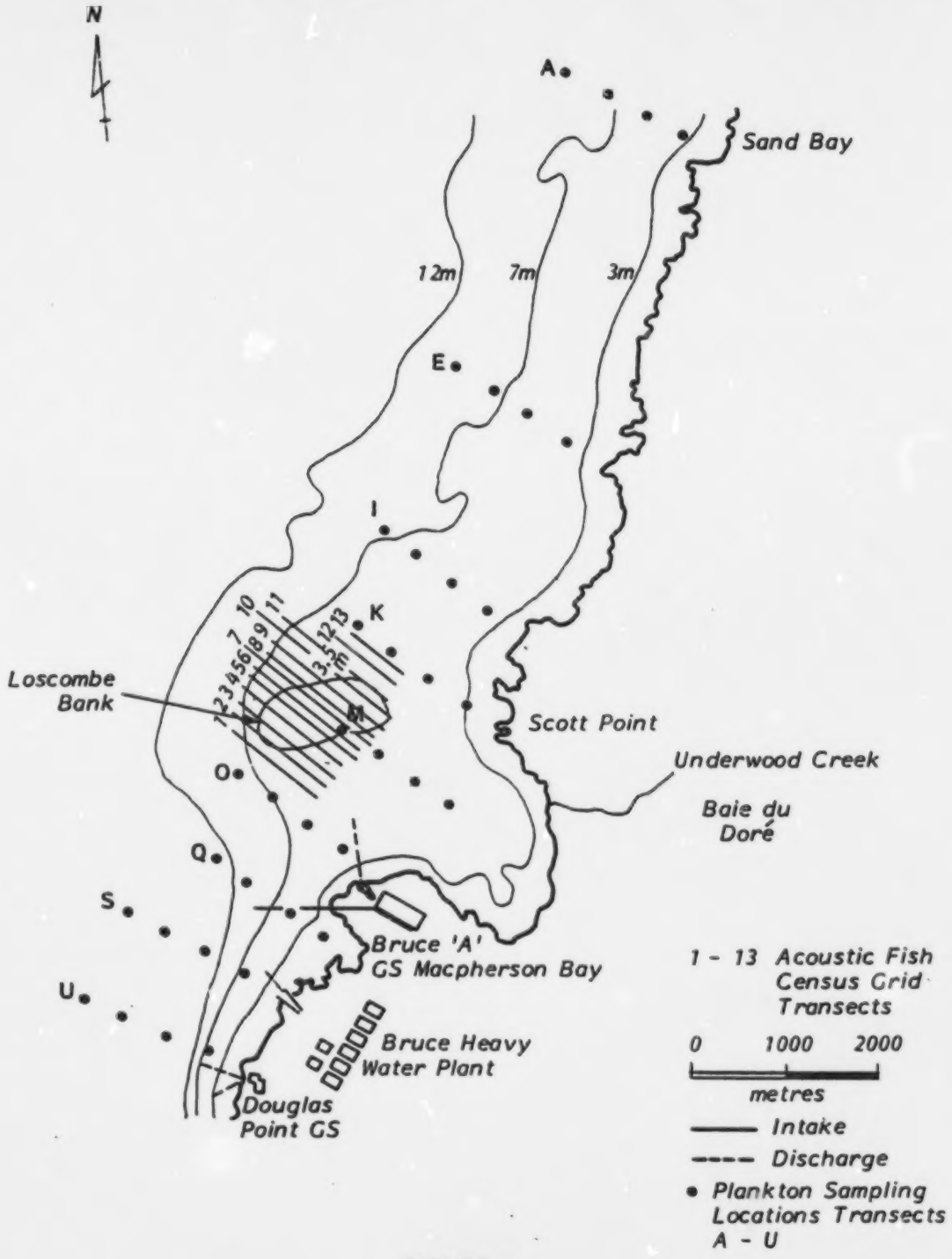

FIGURE 2

LOCATION OF PHYTOPLANKTON, ZOOPLANKTON AND ACOUSTIC FISH CENSUS GRID SAMPLING TRANSECTS AT BNPD, 1979 - 1981

3.1 Sampling Locations and Schedule

The major sampling transects and principal sampling locations used throughout the three-year study are shown in Figure 1. Sampling frequencies are provided in Table 1. Sampling occurred on a monthly basis and extended from May to November in 1979, from May to October in 1980, and from April to November in 1981. Several biological characteristics were sampled only once per year, for example nesting gulls (once in each of 1980 and 1981) and macrophytes (once in 1979)(Table 1).

3.2 Substrate

The substrate was mapped in August (1979 and 1980) along transects from Scott Point to Douglas Point using triplicate (1979) or duplicate (1980) photographs taken from a tripod-mounted, 35 mm underwater camera at 1 m contour intervals (1979) or 250 m intervals (1980) from the shoreline to the 12 m depth contour. Thirty-eight additional substrate sampling locations were in Baie du Doré (1979) and duplicate photographs were also taken 10 m on either side of each transect substrate sampling point and midway between transects at the 3, 7 and 12 m depth contours (1980 only). Substrate particle sizes were determined from a 20% projected area of each slide.

3.3 Sedimentation

PVC sediment tubes were set for two consecutive periods, May to August and August to November, at the 3, 7 and 12 m depth contours along eight transects and at three points along the 3 m depth contour of Baie du Doré in 1979 and 1981 (Figure 1). The 1981 August to November sediment samples were discarded since many tubes were overturned or contained large stones. Rates of accumulation of inorganic and organic material were expressed as g/cm^2/month.

3.4 Water Temperature, Dissolved Oxygen and Transparency

Hydraulic Studies Department provided data on daily water temperature fluctuations in the BNPD nearshore area. Monitoring stations were located at (i) the 2.0 m depth, 0.2 km offshore from Bruce GS 'A' discharge (1979-1981), Bruce GS 'A' intake (1979), Bruce GS 'B' discharge (1980), and Baie du Dore (1979) and (ii) the 2.5 m depth, 1 km southwest of the Great Lakes Institute (GLI) in Baie du Dore (1981).

Vertical temperature profiles, made from surface to bottom at 1 m intervals, were taken monthly from May to October at nine locations (7 m and 12 m contours along the Bruce GS 'A' discharge transect, and 12 m contours at Sand Bay, Scott Point,

TABLE 1

SAMPLING FREQUENCIES FOR EACH DATA TYPE
BNPD, 1979-1981

Data Type	Year	Apr	May	June	July	Aug	Sept	Oct	Nov
Substrate	1979					X			
	1980					X			
Sedimentation	1979		--	------	------	--X--	-----	-----	--X
	1981		--	------	------	--X--	-----	-----	--X
Temperature Profiles	1979		X	X(X)	X	X(X)	X	X(X)	
(Transparency)	1980		X(X)		X(X)	X(X)	X(X)	X(X)	
	1981		X(X)	X(X)	X(X)	X(X)	X(X)	X(X)	
Water Chemistry	1979		X(X)	X(X)	X(X)	X(X)	X(X)	X(X)	
(Dissolved Oxygen	1980		X	X	X	X	X	X	
Profiles)	1981		X	X	X	X	X	0	X
Sediment Chemistry	1979					X			X
Attached Algae:									
Basic Sampling	1979		X	X	X	X(X)	X	X	
(Per Cent Cover)	1981		X	X	X	X(X)	X	X	
Macrophytes:									
Biomass	1979			X	X(X)	X			
(Marsh Transects Mapping)									
Phytoplankton and Zooplankton:									
Basic Sampling	1979		X	X(X)	X	X(X)	X	X(X)	
(Grid Sampling)	1980		X	X	X	X	X	X	
	1981		X	X(X)	X	X(X)	X	X(X)	
Benthic Macroinvertebrates:									
Rock Cages	1979		--	- X	X	X(X)	X	X	
(Vacuum Domes)	1981		--	- X	X	X(X)	0	X	
Adult and	1979-								
Juvenile Fish	1981		X	X	X	X	X	X	
Larval Fish	1979		X	XX	XX	XX			
	1981	XX	XX	XX	XX	XX			
Acoustic Fish Census	1980		X	X	X	X	X	X	
Nesting Gulls	1980		X						
	1981		X						

0 - no sample due to poor weather conditions
X - sample taken

Bruce GS 'A' intake, Macpherson Bay, BHWP discharge, Douglas Point GS discharge and Gunn Point transects) in 1979 and 1981. Dissolved oxygen profiles (1979) and Secchi disc readings (1981) were also obtained at the locations mentioned above. In 1979 Secchi depths were determined at plankton grid sampling locations (Figure 2) during June, August and October. Both water temperature profiles and secchi depth readings were taken in May and monthly from July to October at six locations (Sand Bay - 7 m contour, Scott Point - 12 m contour, Baie du Dore - 3 m contour, and Bruce GS 'A' discharge, Douglas Point GS discharge and Gunn Point - 12 m contour) in 1980.

Horizontal temperature profiles were made in June, August and October, 1979, in conjunction with plankton grid sampling.

Water temperatures were also taken in conjunction with the sampling of phytoplankton, zooplankton, benthic macroinvertebrates and attached algae.

3.5 Water and Sediment Chemistry

Surface water chemistry samples were collected with a PVC Van Dorn sampler monthly from May to October in 1979 and 1980, and from May to November (excluding October) in 1981. Samples were analyzed for several parameters including: total Kjeldahl nitrogen, particulate nitrogen, nitrate, soluble nitrogen, total phosphorous, total silica, soluble silica, non-filtrable and filtrable residues (at 105°C and 550°C), turbidity, calcium, magnesium, pH, and chlorophyll *a*. In addition, samples were analyzed for orthophosphorous in 1980 and 1981, for alkalinity in 1979, and for specific conductance, nitrite, soluble phosphorous and particulate phosphorous in 1979 and 1981.

Sampling locations in 1979 and 1980 included the 3 m contour of Sand Bay and Gunn Point transects and the Bruce GS 'A' forebay. An additional sampling point in 1980 was the 7 m contour of the Bruce GS 'A' discharge transect. In 1981 samples were collected at the Bruce GS 'A' forebay, Bruce GS 'A' discharge (3 m), Sand Bay (12 m) and Gunn Point (12 m).

Subsamples of material taken in sediment tubes at the 7 m contour of BHWP discharge and Gunn Point transects were analyzed for total sulphides in 1979 (Table 1).

3.6 Attached Algae

During May to October, 1979 and 1981, triplicate attached algae samples were obtained monthly from natural substrates at eight shoreline locations (Sand Bay, Transect E, Transect I, Scott Point, Baie du Dore, Macpherson Bay, BHWP discharge and Gunn

Point) (Figures 1 and 2). Shoreline samples were also obtained from five sites within Bruce GS 'A' discharge (Figure 1) in June, August and October, 1979 and 1981, and from two sites (north and south side) within Douglas Point GS discharge in June, August and October, 1979. The June and August 1981 samples from the Bruce GS 'A' discharge were improperly preserved and were not analyzed. A composite map of attached algae per cent cover derived from 1979 and 1981 mapping efforts between Sand Bay and Douglas Point GS is presented in this report.

The species composition of samples was determined and attached algae biomass (for all species found at a given sampling site) was reported as ash-free dry weight in g/m^2. Some errors were found in the attached algae section of the 1979 report (OHRD Report No 82-107-K) and were corrected for this presentation.

3.7 Macrophytes

Marshes and vegetation zones (closed woods, low shrub, wet meadow and shallow marsh) were mapped from Scott Point to Baie du Dore in July, 1979, using both aerial photographs and ground observations. Wet meadow and shallow marsh areas were intensively sampled by placing 1 m^2 quadrats along transects at 5 m intervals. Above-ground standing crop (biomass in g/m^2) was determined in June, July and August, 1979. Species identifications were made where possible (OHRD Report No 82-107-K).

3.8 Phytoplankton and Zooplankton

Phytoplankton and zooplankton samples were collected at the following transects: Sand Bay (7 m), Scott Point (12 m) Bruce GS 'A' discharge (7 m), Baie du Dore (3 m), Douglas Point GS discharge (7 m), and Gunn Point (7 m), and at the Bruce GS 'A' and Douglas Point GS forebays in 1979, 1980, and 1981. Integrated phytoplankton samples were taken with a 3 m PVC tube, while zooplankton samples were collected with a 27 L Schindler-Patalas trap fitted with a 64 µm mesh straining bucket at 0.5 m and at 2.0 m depth intervals from sub-surface to bottom. Zooplankton samples taken at each depth were combined for each location except at Scott Point where samples were kept separate in order to examine the vertical distribution of zooplankton. A 39-point (including three forebay locations) grid sampling scheme was also used in 1979 and 1981 to collect phytoplankton and zooplankton samples during June, August and October (Figure 2). Samples collected in 1981 were stored but not analyzed. In 1979 and 1980 samples were sorted and identified. Zooplankton were enumerated and the densities reported as number/m^3. Phytoplankton biomass was expressed as mg/m^3.

3.9 Benthic Macroinvertebrates

Zoobenthos samples were collected monthly from June to October in 1979 and 1981 by retrieving 2 rock cages from each location (3,7,12 m contours) along eight transects and in Baie du Dore (Figure 1). In order to obtain information on zoobenthic densities on natural substrates a separate 40-point grid sampling scheme was used including points along the eight transects shown in Figure 1, Baie du Dore and Transect E (Figure 2). Triplicate zoobenthos samples were collected at grid points by a 15.2 cm vacuum dome sampler during August, 1979 and 1981. Benthic organisms were sorted, identified and counted. Additional information collected included substrate type, algal cover, depth, temperature and position relative to compensation point.

3.10 Fish

Duplicate nighttime ichthyoplankton samples were obtained bi-weekly from May to August in 1979 and from April to August in 1981. Conical tow nets (50 cm diameter openings, 363 µm mesh) fitted with current meters were used. Sampling locations were along five transects (3, 7, 12 m contours of Scott Point, Bruce GS 'A' discharge, Bruce GS 'A' intake, BHWP discharge and Douglas Point GS discharge), at three (3 m) locations in Baie du Dore (Figure 1), and in three forebays (Douglas Point GS, Bruce GS 'A' and BHWP). Additional samples were obtained at the 1 m contour of the five transects in 1981. Forebay samples taken in April, 1981, were daytime samples. All samples were preserved in 5% formalin, and species densities were expressed as the number of larvae per 1000 m^3 of lakewater.

Adult and juvenile fish were sampled along eight major transects excluding Bruce GS 'A' intake (Figure 1) by 1.2 m trap nets, gill nets and beach seines. Beach seines were mainly used to capture juvenile fish species and two quarter circle sweeps were made monthly at night (at shoreline locations only) with 15.2 m long beach seines (0.64 cm mesh). In 1980 and 1981, beach seining activities were shifted from the north side to the south side of the Douglas Point GS discharge channel to increase fish catch and crew safety. Poor weather conditions prevented beach seine sampling in May and September in 1981.

Trap nets were used to sample the onshore benthic fish community. Two trap nets were set in 2 to 3 m of water for two consecutive 24 h periods.

Experimental gill nets were set on the bottom for a single 24 h period in approximately 3 to 5 m of water perpendicular to shore. In 1979 and 1980 gill nets consisted of eight panels with mesh sizes ranging from 3.8 to 12.7 cm in 1.3 cm

increments. However, an additional mesh size of 2.5 cm was used at all locations in 1980 and at some locations in 1981 including: Douglas Point GS discharge and Gunn Point (all months), Sand Bay (May and June), Scott Point (July), Bruce GS 'A' discharge (August), BHWP discharge (July) and Baie du Dore (May). The calculation of catch per unit effort was restricted to catches obtained from mesh sizes 3.8 cm through 12.7 cm in order to be consistent with the 1979 survey.

Fish captured were identified, counted and examined externally for parasites, disease, injury and spawning condition. Fish stomach analyses (estimating per cent biomass of food items and per cent frequency of occurrence of major food categories) were performed for selected species, and a random sample of up to 20 fish was measured (fork length), weighed and aged in 1979 and 1981. Rock bass *(Amploblites rupestris)* spawning areas in Baie du Dore were mapped weekly during June and July, 1980, by SCUBA divers. Each nest location was marked with an anchored numbered float positioned near the nest. Water temperature was recorded at each nest site.

An acoustic fish census, supplemented by gill net fishing (2.5 to 13.7 cm mesh sizes) to allow identification of fish species, was conducted monthly from May to October (day) and May, June, July and September (night) in 1980 using a grid of 13 transects extending approximately from Scott Point to Macpherson Bay (Figure 2). A high-resolution echo sounder coupled with an automatic echo sorting and logging system was used to obtain fish counts. Temperature profiles were obtained in conjunction with day samples.

3.11 Nesting Gulls

A survey of the nesting gull colony on the landfill area between Bruce GS 'A' discharge and Macpherson Bay was conducted in May, 1980 and 1981. All nests were counted and their distribution mapped, distinguishing between ring-billed and herring gull nests, and the mean number of eggs per nest determined.

4.0 RESULTS AND DISCUSSION

4.1 Physical Characteristics

4.1.1 Operational History of Generating Stations at BNPD

Information on the operating capacity of Bruce GS 'A', BHWP and Douglas Point GS during the study period was obtained from Power History Charts (1980-1982) produced by Nuclear Generation Division. Bruce GS 'A' operated continuously throughout the 1979-1981 sampling period, increasing in average annual

electrical output from a mean net capability factor (including steam production) of 77% (1979) to 91% (1981). Bruce Heavy Water Plant (BHWP) had net capacity factors of 65% and 67% (Enriching Units 1 and 2) in 1979 and 1980, respectively. Enriching Units 1 and 2 of BHWP 'A' operated at 44% in 1981, while Enriching Units 3 and 4 of BHWP 'B' operated at 66% in 1981. Douglas Point GS operated at a net capability factor of about 60% in 1979 and 1981, but only had an output of approximately 16% in 1980 when the station did not operate from February through October.

Figure 3 shows the temperature increases (six day means) across each station and discharge flows (monthly means) for Bruce GS 'A', BHWP and Douglas Point GS during 1979-1981. Variations occurred in the temperature rise across each station, particularly for Douglas Point GS, and to the least extent for Bruce GS 'A'. The temperature differential at Bruce GS 'A' and BHWP was generally higher and had a narrower overall range in 1981 than in 1979 or 1980, perhaps reflecting the increased overall output of the two stations in 1981. The mean temperature differential was highest (11.2C°) for Douglas Point GS during November/December, 1980, and lowest for the same station during October 1979. During the three-year study period all three stations frequently operated well below their design ^{V}T values (11.1C° for Bruce GS 'A' and BHWP, and 11.7C° for Douglas Point GS) (Figure 3).

Discharge flows generally showed little variation throughout the 1979-1981 period for any of the stations at BNPD (Figure 3). Data gaps in Figure 3 represent either instrument malfunction (Bruce GS 'A' and BHWP) or station shutdown (Douglas Point GS). The greatest range in discharge flow occurred at Bruce GS 'A' in 1981 and mean monthly flows were highest for Bruce GS 'A' (168-9 m^3/s) and BHWP (35 m^3/s) during November and May, 1981, respectively. Since the design discharge flow rates are 170 m^3/s, 34 m^3/s and 14 m^3/s for Bruce GS 'A', BHWP and Douglas Point GS, respectively, the flow rate observed at BHWP in May, 1981, slightly exceeded the design value. Otherwise, flow rates were at or below design values for individual stations.

4.1.2 Substrate

Underwater photographs revealed substantial variability in substrate composition in the nearshore zone off BNPD.

The substrate between Scott Point and Bruce GS 'A' discharge (except in Baie du Dore) was largely composed of boulder-cobble materials with some pebble-gravel portions. This substrate pattern contrasted sharply with the predominantly sand-silt bottom found in Baie du Dore (Figure 4). Transport of fine

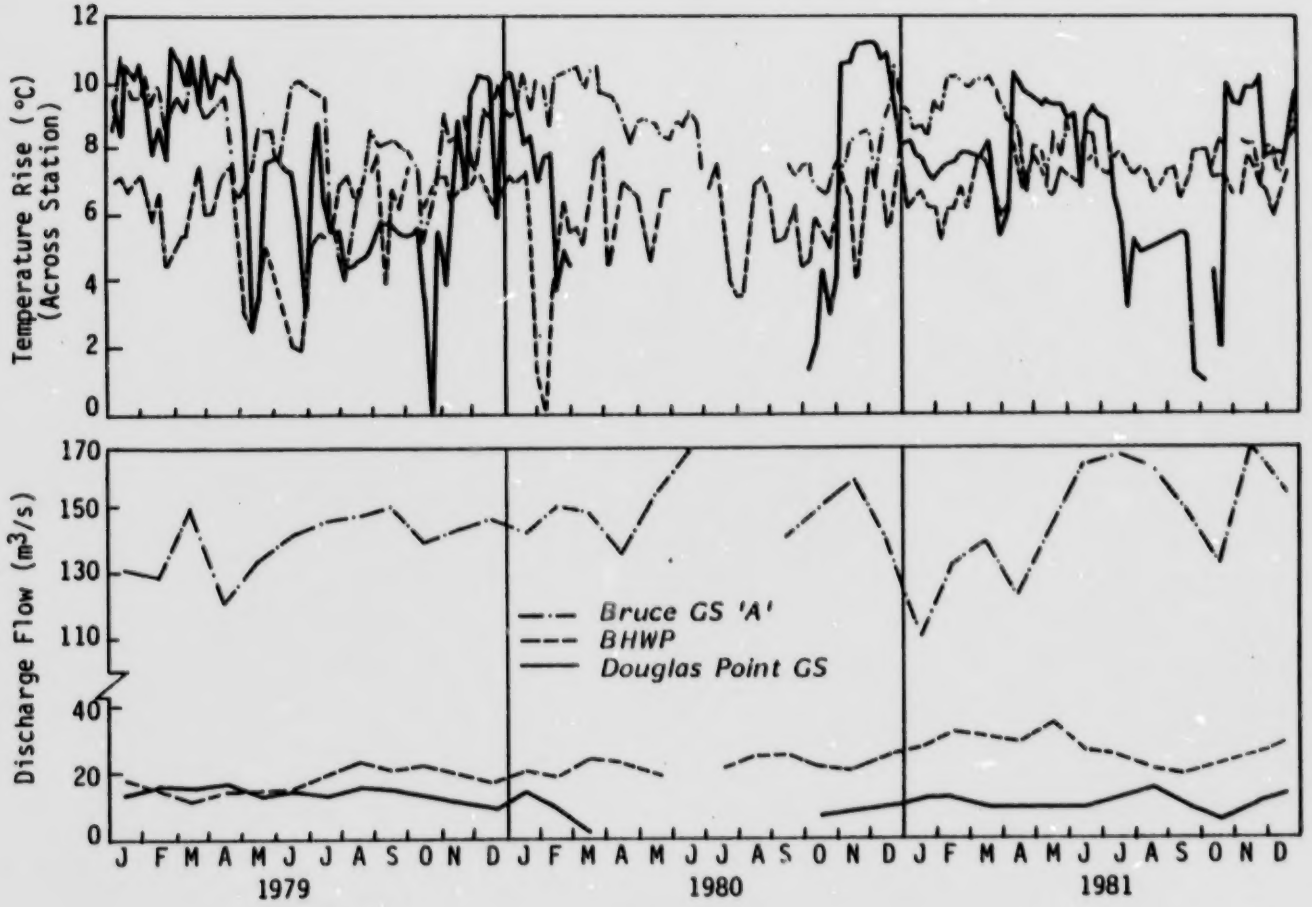

FIGURE 3

ACROSS STATION TEMPERATURE RISES (6 DAY MEANS) AND DISCHARGE FLOWS (MONTHLY MEANS) AT BRUCE GS 'A' BHWP AND DOUGLAS POINT GS DURING 1979, 1980 AND 1981

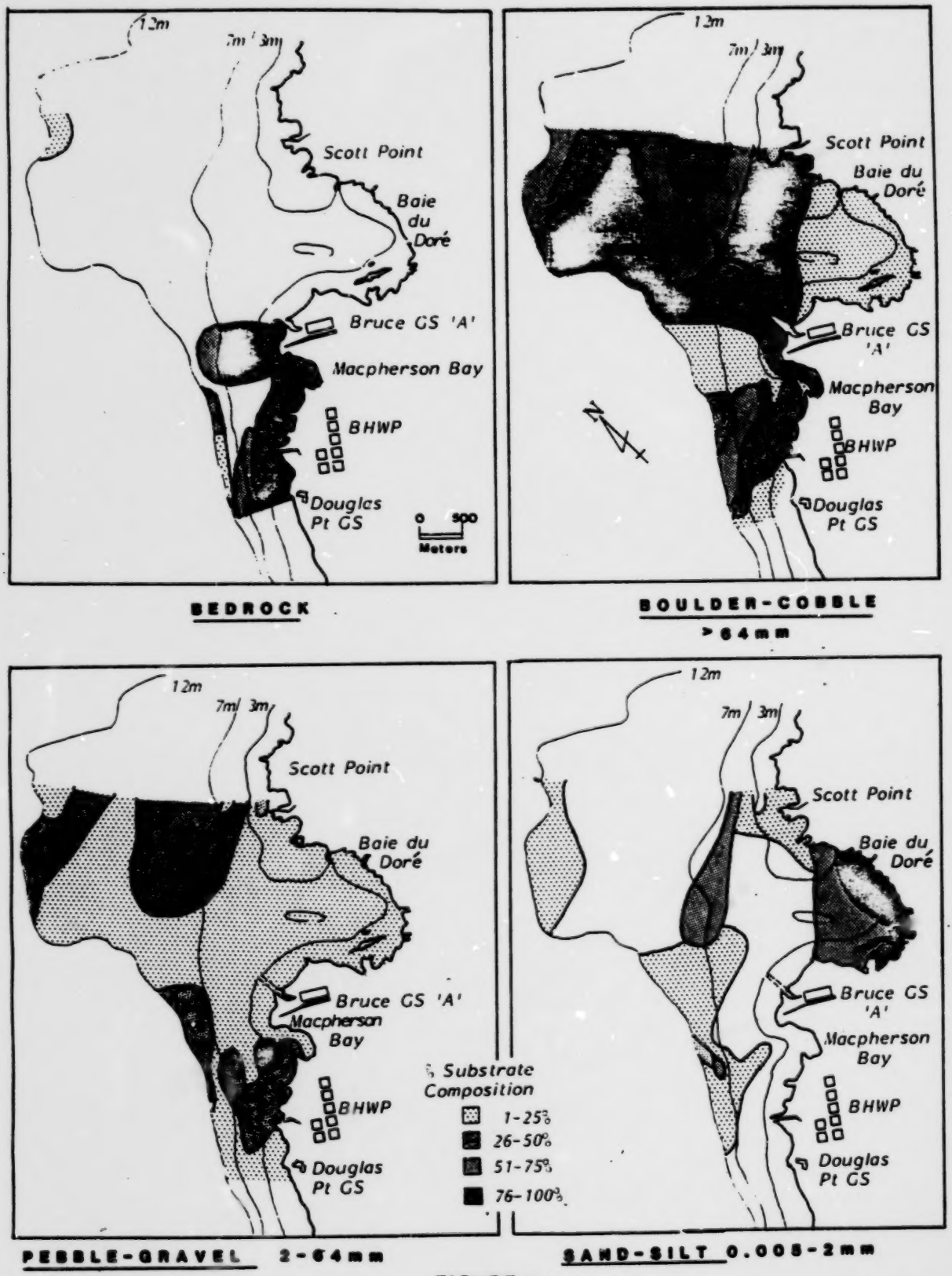

FIGURE 4

PER CENT SUBSTRATE COMPOSITION

AT BNPD 1979-80

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material down Underwood Creek (Figure 1) likely accounted for the predominance of a sand-silt substrate in the inner portion of Baie du Dore. Pockets of pebble-gravel material (not shown on Figure 4) were also noted in Baie du Dore, particularly at deeper locations near the mouth of the bay.

The Bruce GS 'A' intake transect was characterized by exposed bedrock overlain by small concentrations of pebble-gravel substrate. A rather heterogeneous substrate composition was observed at Macpherson Bay (Figure 4). Inshore areas of Macpherson Bay were primarily bedrock while deeper locations exhibited a mix of pebble-gravel and boulder-cobble substrate types. Exposed bedrock was the prevailing substrate at both BHWP and Douglas Point GS discharge locations, although some pebble-gravel and boulder-cobble areas existed, especially at BHWP discharge (Figure 4).

4.1.3 Sedimentation

Sedimentation processes in the inshore zone of freshwater lakes often involve the resuspension of fine-grained particulate matter in the water column. Movement of surface sediments by bottom currents represents a major resuspension method (Bell and Eadie 1983). At BNPD moderately strong, northerly longshore currents prevail and therefore constitute an important force determining sediment flux in the nearshore area.

Mean organic and inorganic sedimentation rates generally declined with increasing distance from shore during the May to August sampling period in 1979 and 1981 (Table 2). However, rates of sedimentation of both inorganic and organic material were higher in 1981 than in 1979 (eg $\overline{X}$ = 0.83 g/cm^2/month versus 0.46 g/cm^2/month for inorganic sedimentation at the 3 m depth contour) (Table 2). The higher overall means in 1981 were primarily due to higher amounts of material accumulating along the Douglas Point GS discharge and Gunn Point sampling transects (3, 7 and 12 m depth contours) (OHRD Report Nos 82-107-K and 83-96-K).

Excavation of the Bruce GS 'B' cooling water intake from May to September, 1981 could have resuspended particulate matter which contributed to the higher sedimentation rates observed along the Douglas Point GS discharge and Gunn Point transects. In 1981 currents near BNPD were bi-directional and parallel to shore about 70% of the time, and averaged 10.1 cm/s (Ontario Hydro Design and Development Division Report No 83336). Northerly and southerly currents each existed about 50% of the time in 1981 and could have transported suspended material to the Douglas Point GS discharge and Gunn Point transects which were within 2 km north and south (respectively) of the Bruce GS 'B' intake excavation

TABLE 2

MEAN SEDIMENTATION RATES (g/cm^2/month)
AT BNPD IN 1979 AND 1981

Depth Contour (m)	Inorganic		Organic	
	1979	1981	1979	1981
May - August				
3	0.46 (0.10-1.08)	0.83 (0.04 - 2.84)	0.03 (0.01 - 0.06)	0.09 (0.01 - 0.30)
7	0.34 (0.08 - 0.74)	0.77 (0.06 - 3.01)	0.02 (0.01 - 0.04)	0.09 (0.01 - 0.30)
12	0.12 (0.08 - 0.51)	0.58 (0.03 - 3.10)	0.01 (<0.01 - 0.02)	0.05 (<0.01 - 0.21)
August - November				
3	1.18 (0.53 - 3.23)	-	0.07 (0.03 - 0.14)	-
7	4.57 (0.53 - 15.09	-	0.20* (0.02 - 0.47)	-
12	1.99 (0.74 - 3.75)	-	0.11 (0.04 - 0.24)	-

- No data available
* Original value incorrect in 1979 report (82-107-K)

Range in parentheses

area. At a mean current speed of 10.1 cm/s the approximate transport time of suspended material to a point 2 km from the excavation site would have been 5 - 6 h.

Particulate matter generated by wave-induced shoreline erosion likely contributed to the sediment flux in the nearshore BNPD area in both 1979 and 1981. It is not possible to comment on the relative contribution of normal inshore sedimentation processes and construction activity at the Bruce GS 'B' intake site to sedimentation rates observed at BNPD in 1981.

Inorganic and organic sedimentation rates during the August to November period greatly exceeded (by at least a factor of 2) those of the May to August period (1979) (Table 2). A heavier resuspension of particulate matter due to high fall winds probably gave rise to the higher fall sedimentation rates. Variability in the rate of organic and inorganic sedimentation among the BNPD sampling locations was greater during the fall rather than summer sampling period (1979). There was a tendency for fall sedimentation rates (August to November period) to be higher at more northerly transects such as Sand Bay and Scott Point, particularly at 3 m and 12 m contour locations (OHRD Report No 82-107-K). Discharge locations generally had rates of sedimentation which were comparable to other sampling locations, except for locations along the Douglas Point GS discharge transect during May to August, 1981 (as described above).

The mean per cent organic content of sedimented material varied with depth and among transects in both summer (1979 and 1981) and fall (1979) sampling periods, ranging from 3.7% to 15.1%. However, no apparent trend in organic content of sedimented material was observed.

4.1.4 Water Temperature, Dissolved Oxygen and Transparency

Water Temperature

During the 1979-1981 period mean daily water temperatures were recorded at the 2.0 m depth 0.2 km offshore from the Bruce GS 'A' discharge and compared with corresponding temperatures at the Bruce GS 'A' intake transect (1979), Baie du Dore (1979 and 1981) and the Bruce GS 'B' discharge transect location (1980). Water temperatures for 1979, 1980 and 1981 are shown in Figure 5. The Bruce GS 'A' discharge temperature monitoring point was normally within the thermal plume area (Ontario Hydro Design and Development Report No 83336).

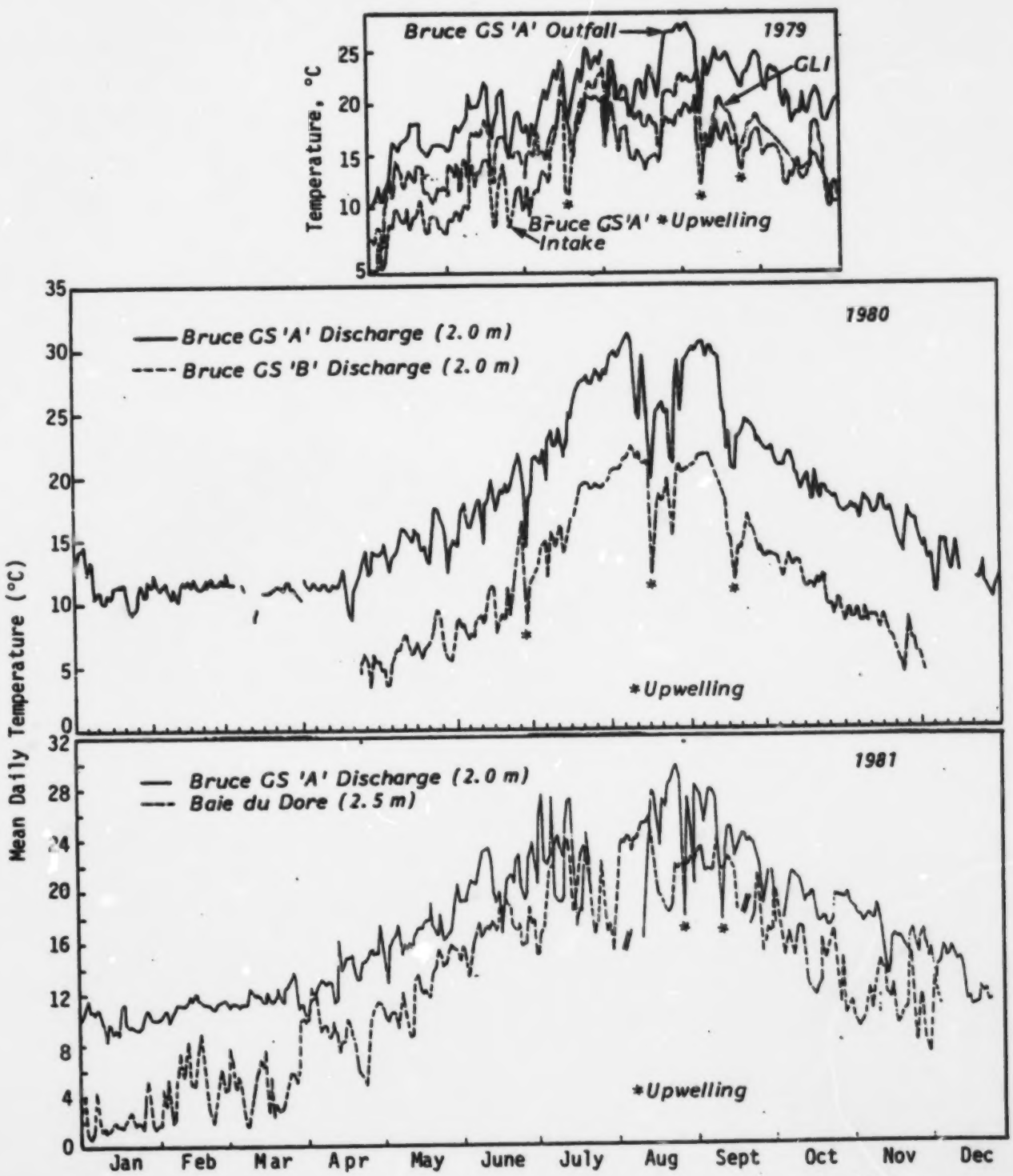

FIGURE 5

MEAN DAILY TEMPERATURES RECORDED AT BNPD DURING 1979, 1980 AND 1981

The main trend in mean daily water temperatures recorded at Bruce GS 'A' discharge in each sampling year was a gradual increase in water temperature during the spring followed by peak mid-summer temperatures near 30°C and then a decline to temperatures between 8 to 12°C in late fall and winter (Figure 5). In 1981 the area influenced by the discharge represented a more thermally stable environment during winter and spring than Baie du Dore. The Bruce GS 'A' discharge may have had a reduced influence on adjacent water masses (Baie du Dore) during the winter.

Seasonal temperature fluctuations similar to those observed in Bruce GS 'A' discharge occurred at other sampling points. Baie du Dore water temperatures were normally intermediate between those of Bruce GS 'A' discharge and either Bruce GS 'A' intake or Bruce GS 'B' discharge locations (Figure 5) reflecting the fact that the latter two locations were more indicative of open lake conditions while Baie du Dore represented a sheltered, shallow bay.

A conspicuous feature of the thermal regime near BNPD was the occurrence of frequent major upwellings during the summer months. These upwellings were particularly evident in 1979 and 1980 and to a lesser extent in 1981, and were characterized as large rapid drops in temperature (>5°C) lasting 24 to 48 h (Figure 5). Upwellings were apparent and of similar magnitudes in both discharge and ambient water temperature records.

Vertical temperature profiles obtained in 1979, 1980 and 1981 showed that inshore waters near BNPD did not normally begin to stratify until June and that isothermal conditions were restored by September or October. These patterns are illustrated by the 1981 temperature profile at the 12 m contour of the Bruce GS 'A' discharge transect (Figure 6). The addition of a 7 m depth contour sampling location along the Bruce GS 'A' discharge transect in 1980 and 1981 demonstrated that thermal gradients existed on all sampling occasions (Figure 6), providing evidence of the warm surface plume emanating from Bruce GS 'A' discharge. Further, vertical thermal stratification persisted later in the year at the 7 m Bruce GS 'A' discharge location (Figure 6).

Horizontal temperature profiles (obtained in 1979 only) indicated that elevated temperatures occurred along the Bruce GS 'A' discharge and Scott Point transects and at the mouth of Baie du Dore (OHRD Report No 82-107-K). This observation is consistent with the fact that the thermal plume from the Bruce GS 'A' discharge is frequently directed to the northeast, across the mouth of Baie du Dore (Ontario Hydro Design and Development Report No 83336).

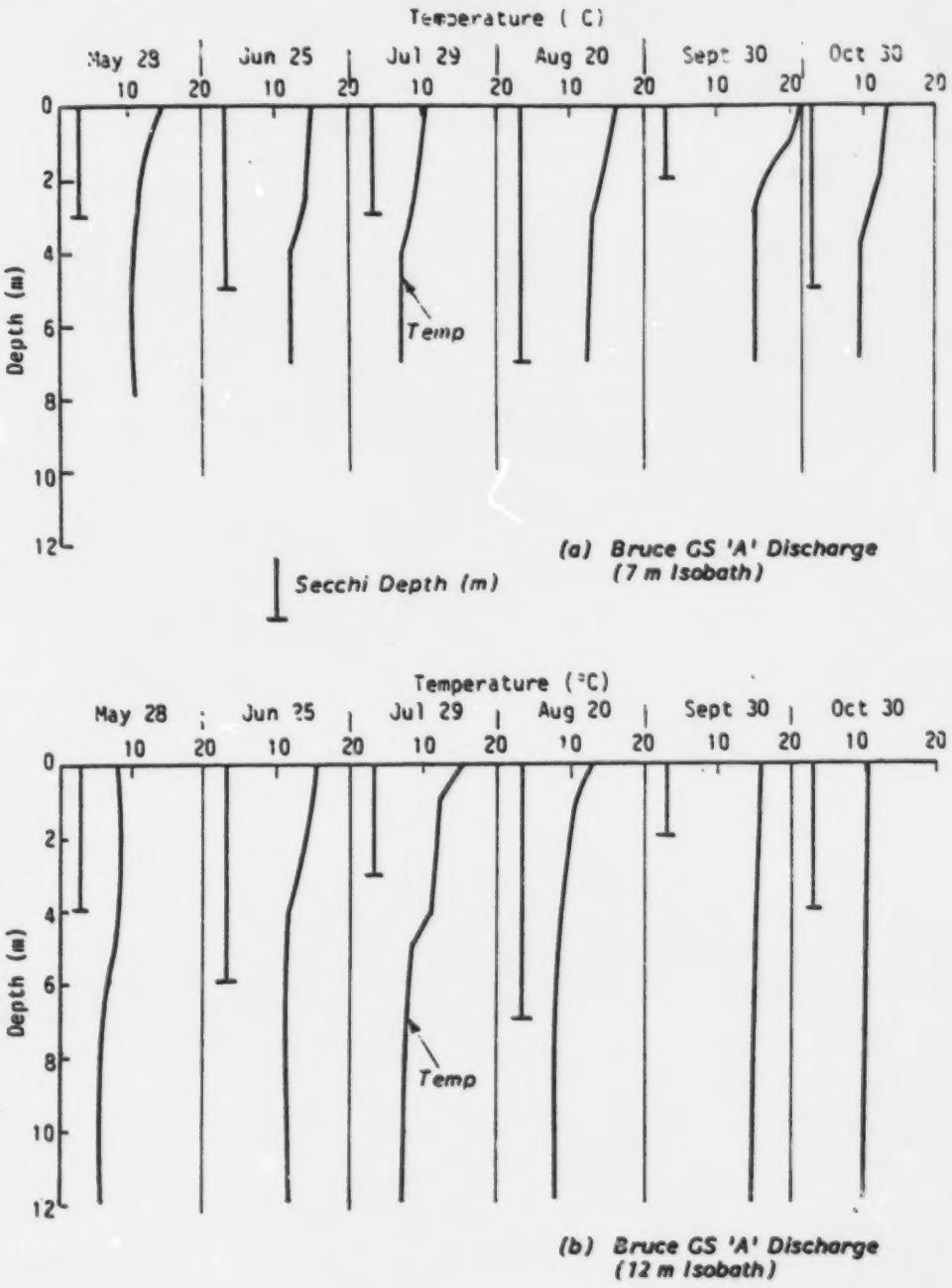

FIGURE 6

SECCHI DISC TRANSPARENCY DEPTHS AND VERTICAL TEMPERATURE PROFILES AT THE a) 7 m AND b) 12 m ISOBATHS FOR BRUCE-GS 'A' DISCHARGE - BNPD, 1981

Dissolved Oxygen

Dissolved oxygen levels measured in 1979 ranged from 7.2 to 13.5 ppm and did not vary substantially in a vertical direction or among transects, but generally approximated or slightly exceeded saturation levels at the corresponding temperatures (OHRD Report No 82-107-K).

Water Transparency

Water transparency showed temporal variation in both 1979 and 1981. Maximal water clarity occurred in August (Figure 6). Secchi depth readings were generally smallest (indicating low transparency) in May/June or September/October and thus were probably related to the amount of resuspended particulate matter in the water column during spring and fall turnover of the lake (Wetzel, 1975). Fall storms may also have contributed to a higher level of particulate matter in the water column, thus decreasing water clarity during September.

Measurements of Secchi depth in 1979 indicated that water transparency fluctuated in a longshore direction during August and October, with mean values of 3.8 to 3.0 m at the northernmost transects (Sand Bay and Scott Point), and 8.0 to 8.8 m at the southernmost transects (Douglas Point GS, BHWP and Gunn Point). Bruce GS 'A' discharge was characterized by mean Secchi depth values intermediate between these two extremes. No longshore gradient in transparency was observed during June, 1979 (OHRD Report No 82-107-K). Water clarity increased slightly with distance from shore at most locations sampled in October, 1979.

It is noteworthy that during the August to November period (1979) inorganic sedimentation rates were generally greater at the northern rather than southern sampling locations (OHRD Report No 82-107-K). This trend corresponds to the longshore transparency gradient mentioned earlier for the August and October sampling periods. Longshore varability of Secchi depths was minimal in 1981 (OHRD Report No 83-96-K).

4.1.5 Water and Sediment Chemistry

Water quality conditions in the nearshore area off BNPD were generally very similar during the 1979-1981 period (Table 3). Concentrations of most chemical parameters reflected the oligotrophic status of Lake Huron (Kwiatkowski, 1980).

The range of total phosphorous levels near BNPD was 6 to 40 µg/L in 1979, <10 to 17 µg/L in 1980 and 5 to 19 µg/L in 1981 (OHRD Report Nos 82-107-K, 82-182-K and 83-96-K). Highest total phosphorous levels occurred in May or June at all sampling

TABLE 3

MEAN VALUES OF VARIOUS WATER QUALITY PARAMETERS COLLECTED MONTHLY AT BNPD FROM MAY TO OCTOBER (OR NOVEMBER) DURING 1979-1981

Water Quality Parameter	Sand Bay			Bruce GS 'A' Discharge			Bruce GS 'A' Forebay			Gunn Point		
	1979 (3 m)	1980 (3 m)	1981 (12 m)	1979	1980 (7 m)	1981 (3 m)	1979	1980	1981	1979 (3 m)	1980 (3 m)	1981 (12 m)
pH	7.8	8.3	8.0	-	8.2	8.0	7.9	8.3	8.0	7.8	8.3	8.1
Specific conductance (mS/m)	17.9	-	18.4	-	-	18.9	18.4	-	18.9	18.3	-	18.8
Turbidity (NTU)	1.4	1.5	1.3	-	0.8	1.3	1.1	0.9	1.2	1.0	0.9	1.3
Non-filtrable residues at 105°C (mg/L)	2.8	2.1	2.5	-	0.9	1.6	1.7	3.5	1.6	1.1	1.4	2.3
Non-filtrable residues at 550°C (mg/L)	2.0	1.7	1.7	-	0.7	1.1	1.3	2.6	1.2	0.9	0.7	1.4
Filtrable residues at 105°C (mg/L)	123	120	121	-	123	118	119	121	118	123	124	121
Filtrable residues at 550°C (mg/L)	99	96	96	-	99	90	96	94	90	98	98	94
Total phosphorous (µg/L)	6	10	10	-	10	9	19	12	13	20	10	10
Soluble phosphorous (µg/L)	11	-	7	-	-	6	11	-	9	11	-	8
Particulate phosphorous (µg/L)	6	-	3	-	-	3	6	-	5	6	-	2
Filtrable orthophosphorous (µg/L)	10	-	7	-	-	6	12	-	8	10	-	6
Total Kjeldahl nitrogen (mg/L)	0.24	0.18	0.45	-	0.16	0.32	0.16	0.15	0.33	0.15	0.15	0.40
Soluble nitrogen (mg/L)	0.15	0.50	0.37	-	0.13	0.28	0.13	0.13	0.30	0.12	0.13	0.34
Particulate nitrogen (mg/L)	0.08	0.04	0.01	-	0.05	0.03	0.05	0.04	0.03	0.05	0.04	0.04
Nitrite (mg/L)	<0.05	-	<0.01	-	-	<0.01	<0.05	-	<0.01	<0.05	-	<0.01
Nitrate (mg/L)	1.0	1.2	1.2	-	1.3	1.3	1.0	1.3	1.4	1.2	1.2	1.2
Total silica (mg/L)	1.54	1.17	1.45	-	1.30	1.53	1.34	1.31	1.64	1.19	1.23	1.54
Soluble silica (mg/L)	0.82	0.80	1.10	-	1.07	1.03	1.02	1.17	1.16	0.98	1.05	0.96
Calcium (mg/L)	26.1	25.6	26.9	-	25.4	27.0	26.1	25.7	26.9	25.9	25.7	26.5
Magnesium (mg/L)	7.0	7.1	7.2	-	7.0	7.1	6.9	7.1	7.1	7.0	7.1	7.0
Chlorophyll *a* (µg/L)	1.2	1.4	1.2	-	1.5	1.1	0.9	1.8	1.2	1.0	1.4	1.2

locations (Sand Bay, Bruce GS 'A' discharge, Bruce GS 'A' forebay and Gunn Point). Mean total phosphorous levels were higher in 1979 than in 1980 and 1981 (Table 3). The high spring concentrations of total phosphorous corresponded closely to the high spring peak in phytoplankton biomass values observed in 1979 (see Section 5.3). Mean concentrations of soluble and particulate phosphorous and orthophosphorous declined between 1979 and 1981 (Table 3).

Total Kjeldahl nitrogen includes organic nitrogen and ammonia but not nitrite or nitrate. Highest total Kjeldahl nitrogen concentrations generally occurred in June and September during each year, with lower values recorded in July and August. Mean concentrations of this parameter were similar in 1979 and 1980 and increased in 1981 (Table 3). Sand Bay had the highest mean levels of total Kjeldahl nitrogen in each survey year. Soluble but not particulate nitrogen concentrations increased in 1981 (Table 3).

Nitrite levels were below the limit of detection in the BNPD nearshore area. Nitrate concentrations were relatively stable over the three-year period, with mean values ranging from 1.0 to 1.4 mg/L (Table 3).

The highest value of soluble silica in each year usually occurred in May followed by a sharp decrease in June which was most likely associated with removal by diatoms. Values of this parameter ranged from 0.33 to 1.44 mg/L over the entire study period, with mean concentrations at Bruce GS 'A' forebay in 1980 and 1981 being higher than those recorded at other locations (Table 3). Total silica levels were on the average higher in 1981 than in 1979 or 1980 and were also maximal at Bruce GS 'A' forebay with the exception of the Sand Bay location, where the highest mean level was recorded in 1979 (Table 3).

Chlorophyll *a* concentrations were highest in June and September in 1980 and 1981 (OHRD Report Nos 82-182-K and 83-96-K). In 1979, mean concentrations ranged from only 0.9 to 1.2 µg/L (Table 3). Maximum levels of chlorophyll *a* observed in 1980 ranged from 2.3 to 3.6 µg/L among the four locations sampled (OHRD No 82-182-K) and corresponded temporally to high phytoplankton biomass values (Section 5.3). The highest chlorophyll *a* levels measured in 1980 resulted in mean chlorophyll *a* concentrations higher than those of 1979 and 1981, particularly in Bruce GS 'A' forebay where the mean chlorophyll *a* concentration in 1980 was twice that recorded in 1979 (Table 3). Despite the considerable variation in mean chlorophyll *a* concentrations between sampling years, the overall range (0.9 to 1.8 µg/L) was characteristic of low productivity oligotrophic waters (Kwiatkowski, 1980).

Mean levels of non-filtrable and filtrable residues were generally not substantially different from year to year (Table 3). Rather high mean levels of non-filtrable residues (at 105°C and 550°C) occurred at the Bruce GS 'A' forebay in 1980, a result of exceptionally high June levels of this parameter (OHRD Report No 82-182-K). Temporal variation of non-filtrable matter was minimal in 1979 (all locations) with maximum values recorded in May (OHRD Report No 82-107-K). Both spring (May) and fall (early November) values obtained in 1981 were greater than midsummer values, resulting in mean levels higher than those of previous years (Table 3). There was a close correspondence between the high non-filtrable residue levels (June, 1980 and May and November, 1981) and turbidity levels recorded in the same months, and these together with sedimentation data presented earlier (Section 4.3) strongly indicate the resuspension of fine particulate material in the BNPD area, especially at Sand Bay and Gunn Point locations.

Filtrable residue concentrations (both at 105°C and 550°C) were relatively consistent among locations and months sampled, and showed little variation between years. Levels appeared to be slightly depressed in spring and fall, 1980 and 1981.

Specific conductance levels were generally highest during spring (May) of each year. Average concentrations were similar among locations and between years with the maximum difference being 1.0 mS/m (Table 3).

Mean calcium and magnesium concentrations did not vary substantially between years. Mean pH values were slightly higher in 1980 than in 1979 or 1981 (Table 3).

Sediments analyzed for metal sulphide complexes in 1979 contained <25 mg/kg of total sulphides (below the limit of detection) at both BHWP and Gunn Point locations (OHRD Report No 82-107-K).

4.2 Biological Characteristics

4.2.1 Attached Algae

A. Species Composition

Sixteen taxa of attached algae were identified in the shoreline samples in 1979. Nineteen taxa were identified in 1981, of which nine were found in 1979 (Table 4). Some of the differences probably represent a shift in species composition (eg, the appearance of *Bulbochaete* and *Calothrix* in 1981), but others may reflect difficulties in distinguishing between similar species

TABLE 4

TAXA OF ATTACHED ALGAE AND EPIPHYTES FOUND IN THE SHORELINE SAMPLES AT BNPD IN 1979 AND 1981

Attached Alage	1979	1981
Anabaena		X
Bulbochaete		X
Calothrix		X
Chaetonema	X	
Cladophora glomerata	X	X
Cladophora		X
Ccleochaete		X
Cylindrocapsa	X	
Dichothrix	X	X
Lyngbya	X	
Microspora	X	
Mougeotia	X	X
Oedogonium	X	X
Oscillatoria		X
Pithophora	X	
Plectonema		X
Protoderma	X	
Rhizoclonium		X
Schizothrix		X
Scytonema	X	X
Spirogyra	X	X
Stigeoclonium		X
Synedra montana	X	
Ulothrix	X	X
Ulothrix zonata	X	X
Zygnema	X	X
Epiphytes		
Chamaesiphon	X	
Cocconeis	X	X
Cymbella	X	X
Diatoma	X	
Gomphonema	X	
Rhoicosphenia curvata		X
Synedra	X	
Unidentified (2)	X	

(e.g. *Lyngbya and Oscillatoria)*, particularly when the sample material is in poor condition, or because of the occasional inclusion of less common species in a sample.

Considerable temporal and spatial heterogeneity was apparent in attached algae species composition over the study period (Figure 7). In 1979 *Ulothrix* spp were dominant at most locations until the end of July, while either *Mougeotia* or *Cladophora* spp were prominent from August to October. In contrast one or more of *Mougeotia, Bulbochaete* and *Calothrix* was more common in June and July, 1981. *Cladophora* spp, prevalent at several locations in 1979, were abundant only at Gunn Point in September of 1981 (Figure 7). Reasons for the change in seasonal pattern between 1979 and 1981 are unknown, but the change is unlikely to have been caused by thermal discharges since it occurred at discharge as well as non-discharge sampling sites.

Eight epiphytic taxa were identified on the attached algae from the shoreline in 1979. Only three were present in 1981 (Table 3). In neither year were any species uniquely associated with the attached algae in the discharge locations. In 1979 epiphytes were rare before August, but from August to October, epiphytes were found at most of the BNPD sampling locations. *Cymbella* and *Gomphonema* were the most common genera in 1979 (OHRD Report No 82-107-K). In 1981 *Cymbella* was the most common genus, occurring at most locations almost every month. *Rhoicosphenia* was present only in May 1981 (OHRD Report No 83-96-K). The change in species composition of the epiphytic algae between 1979 and 1981 may have resulted from the change in species composition of the attached algae.

Analysis of samples from the five locations within the Bruce GS 'A' discharge indicated that unique patterns of species changeover occurred at each location during the 1979 growing season (OHRD Report No 82-107-K). June dominants were *Oedogonium* (area 1, Figure 1), *Cladophora* (area 2) and *Ulothrix* (areas 3, 4 and 5). In August a different species dominated each location. *Ulothrix* was the only species which persisted as a dominant from June to August (area 3). August dominants at the remaining locations were *Zygnema* (area 1), *Oscillatoria* (area 2), *Lyngbya* (area 4) and *Stigeoclonium* (area 5). *Mougeotia* dominated areas 1, 2 and 3 in October, *Zygnema*, area 4 and *Cladophora*, area 5.

In October of 1981 the species composition at the five discharge sites was more uniform than that observed in 1979. *Mougeotia* or *Stigeoclonium* was either the dominant or codominant species at each location (OHRD Report No 83-96-K).

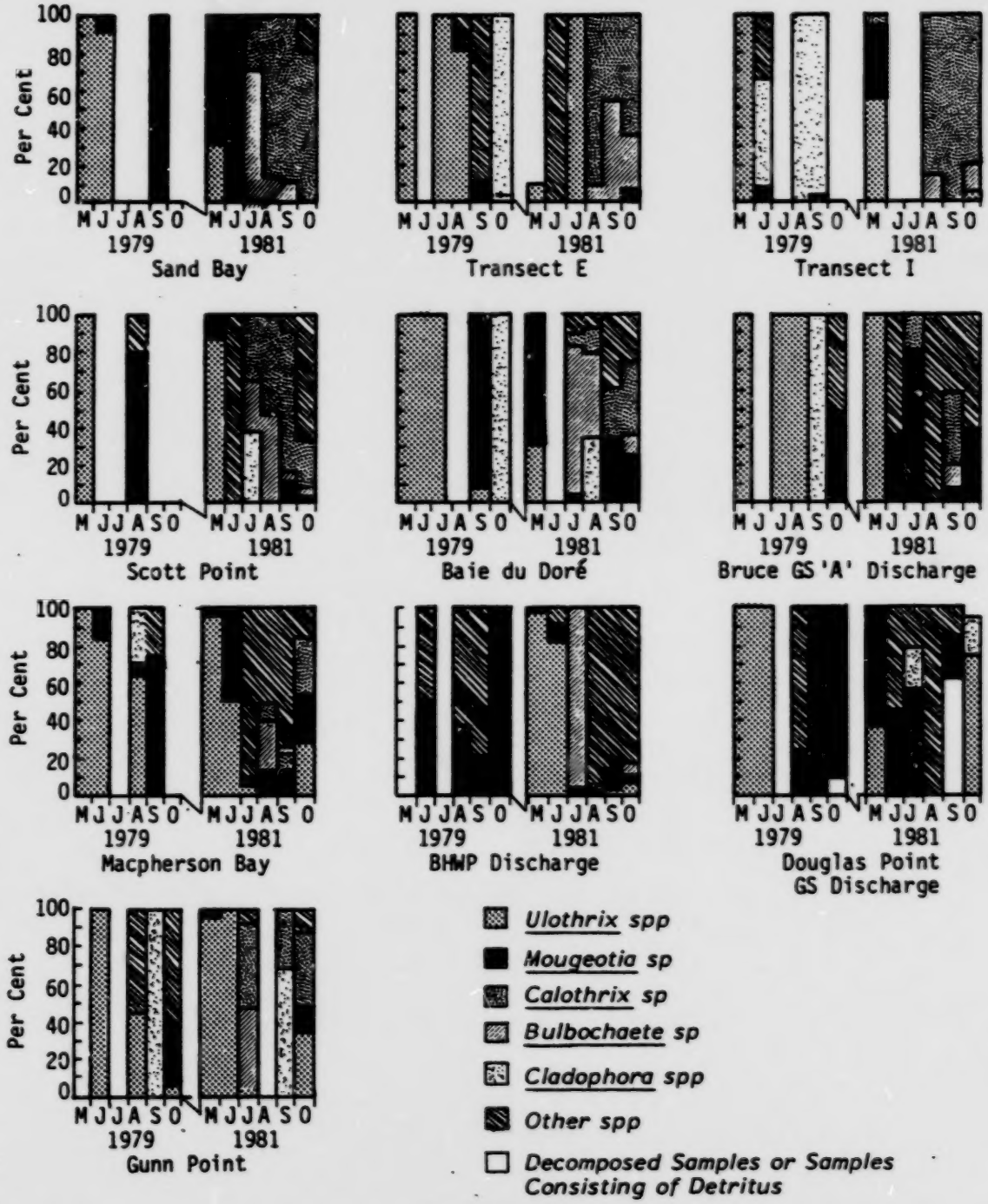

FIGURE 7

PER CENT COMPOSITION OF ATTACHED ALGAE AT BNPD SAMPLE LOCATIONS IN 1979 AND 1981

The spatial differences in 1979 were attributed in part to differences in flow among the five locations (OHRD Report No 82-107-K). Areas 3 and 5 at the mouth of the discharge were exposed to the most water movement and had the lowest overall percentages of the Zygnematales *(Mougeotia* and *Zygnema)*, an order of relatively weakly attached species suited to somewhat protected areas. Temperature was not a factor affecting the spatial distribution of attached algae, since the temperature at the five areas was virtually identical (OHRD Report No 82-107-K).

Samples from Douglas Point GS discharge (1979 only) were dominated by the Zygnematales in August and October. No algae were found on the south side in June while *Ulothrix zonata* dominated the north side of the discharge. The similarity in species composition found at the north and south sides of Douglas Point GS discharge is somewhat surprising since the north side of the channel was more exposed to flow from the discharge. Other factors (such as substrate stability) may have influenced the attached algae species composition in Douglas Point GS discharge.

At the six deeper locations sampled (Gunn Point - 1 m, 3 m, 7 m, 12 m; Sand Bay - 3 m; Baie du Dore - 3 m) there was little overlap in species composition between 1979 and 1981. *Ulothrix* and *Cladophora glomerata* were the most common species found along the Gunn Point transect in 1979, while *Calothrix* and *Bulbochaete* were most common in 1981. Algae were found closer to shore (1 m contour) at Gunn Point in 1979, but were more prevalent in deeper water (3 m, 7 m and 12 m contours) in 1981. The reasons for either the change in species composition or the shift in depth distribution between years are not known.

Cladophora glomerata was the only algae which occurred at Sand Bay in 1979 and was found in August at the 3 m contour. *Cladophora* was not found in 1981 when the dominant species were *Mougeotia* and *Calothrix*.

Algae were similarly sparse at the 3 m contour sampling point in Baie du Dore in 1979, occurring only in June. Two species *(Cladophora glomerata* and *Mougeotia)* were found in 1979 compared to the seven identified in 1981, when *Bulbochaete, Calothrix* and *Scytonema* were prominent.

B. Biomass

The biomass data were characterized by a high degree of temporal and, to a lesser extent, spatial variability. The maximum ash free dry weight for a single sample was 300.16 g/m^2 from the Bruce GS 'A' discharge in June of 1979 (OHRD Report

No 82-107-K). Most samples were less than 50 g/m^2. The ash free dry weights of samples from the discharge areas generally fell within the range for samples from the remaining locations, both in 1979 and 1981. This suggests that the discharge of the heated effluent has not had a significant impact on algal biomass. However, a visual assessment of sites in 1981 suggested that the algae at Bruce GS 'A' discharge, Douglas Point GS discharge and Great Lakes Institute (GLI) had substantially higher biomasses than the remaining shoreline locations (R. Sheehan, pers comm). The inability to detect any large differences in biomass between locations (other than at Bruce GS 'A' discharge in June, 1979) may have resulted from the inclusion of variable amounts of detritus, sand and silt in some samples. These components lead to an overestimate of algal standing crop. Methods have not yet been developed which enable sampling of only algal material or which permit effective removal of debris from the samples in the laboratory.

Samples collected from variable depths at Gunn Point, Baie du Dore and Sand Bay generally contained less than 50 g/m^2 ash free dry weight. No trend with depth was apparent, but the data are subject to sampling errors such as those described above.

C. Distribution

A map showing the per cent bottom cover of attached algae along the sampling transects in August, 1979 and 1981 is presented in Figure 8. The distribution of algae was patchy. Highest per cent cover was observed along the Bruce GS 'A' discharge transect and near cottages in the area between Sand Bay and Scott Point (Figure 8). Lower per cent cover was observed at the BHWP discharge and at the Douglas Point GS discharge. Per cent algal cover in Baie du Dore was generally sparse.

The distribution of algae is explicable by a combination of factors including substrate, nutrients, current and water temperature. Some areas with a low per cent algal cover, such as Baie du Dore, had a large proportion of small sized particles in the substrate (see Section 4.1.2). Movement of the finer substrate by currents and wave action may render them unsuitable for attachment of algal filaments. The high cover in the vicinity of the cottages is likely to have arisen from a combination of suitable substrate and high nutrient inputs. Similarly, the high cover near the Bruce GS 'A' discharge may be related to a combination of high water temperature during the growing season and suitable substrate (boulder/cobble and bedrock). Consistent with this hypothesis is the lower algal cover found near BHWP and Douglas Point GS which had smaller thermal outflows than Bruce GS 'A'. In addition, high discharge currents may favour the growth of algal species which are strongly attached to the substrate.

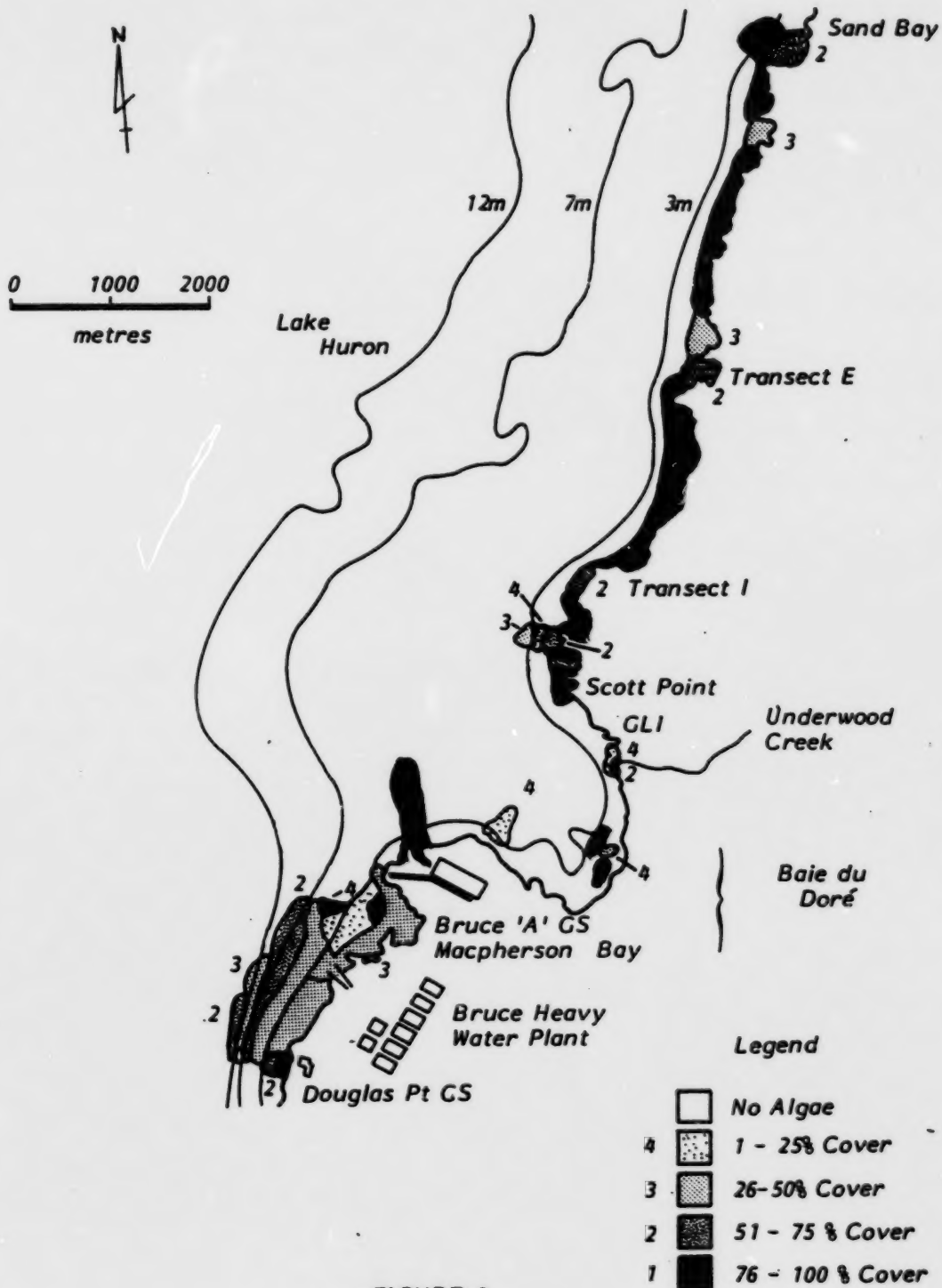

FIGURE 8

COMPOSITE PER CENT ALGAL COVER MAP
BNPD - 1979 AND 1981

On inspection the algal cover in the Bruce GS 'A', Douglas Point GS and the BHWP discharges and in the vicinity of the cottages appeared more lush than at other locations. For example, strands in the Bruce GS 'A' discharge averaged about 5 cm in length and were relatively free of sediment and detritus (Plate I). Algae at the remaining locations were characterized by short filaments which were completely covered with silt and detritus, eg at Macpherson Bay (Plate II).

4.2.2 Macrophytes

The principal shore marsh area sampled in 1979 near BNPD was located in the southeastern corner of Baie du Dore (Figure 9). An additional marsh surrounded an island in the south portion of the bay. The four main vegetation zones identified were (1) closed woods, (2) low shrub and intermittent trees, (3) wet meadows and (4) shallow marsh. These zones covered areas of 15.3, 20.0,18.6 and 16.2 ha, respectively. Only the wet meadow and shallow marsh zones were sampled intensively (OHRD Report No 82-107-K).

The wet meadow zone was characterized by a high cover of sedges of the genus *Carex* and a high cover of grasses intermixed with a variety of flowering herbs and occasional shrubs. Bluejoint *(Calamagrostis canadensis)* was the most abundant grass found, while common herbs noted were boneset *(Eupatorium perfoliatum)*, goldenrod *(Solidago* sp) and silver weed *(Potentilla anserina)*. Shrubs included dogwood *(Cornus stolonifera)*, shrubby cinquefoil *(Potentilla fruticosa)* and meadow sweet *(Spiraea alba)*. The water table in this zone is normally situated at or near the soil surface during the growing season, but the meadow zone may be inundated in early spring or after heavy rainfall.

Emergent rushes *(Juncus* spp), bulrushes *(Scirpus* spp) and spike rushes *(Eleocharis* spp) dominated the shallow marsh zone. At water depths of 20 cm or more, submergents such as pondweeds *(Potamogeton* spp), tape grass *(Vallisneria* sp) and milfoil *(Myriophyllum spicatum)* often formed a second layer. Standing water occurred in this zone throughout the year.

Spatial variations in species density and stature existed with both wet meadow and shallow marsh zones, and were attributed to local variations in water current, wind exposure, topography and substrate (OHRD Report No 82-107-K). This was particularly evident in the shallow marsh zone around the island where the vegetation in the southeast was relatively sparse and of low stature.

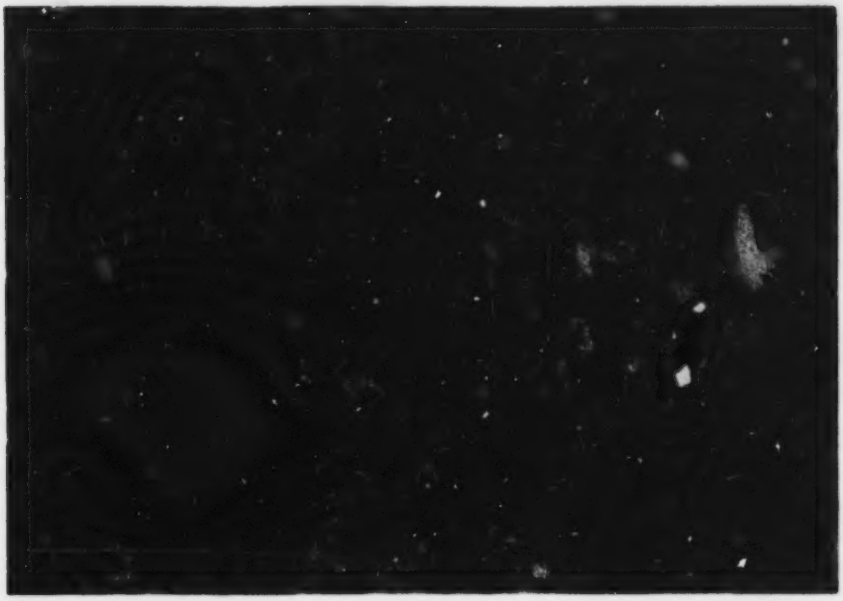

PLATE I
ATTACHED ALGAE AT BRUCE GS 'A' DISCHARGE DURING 1979

PLATE II
ATTACHED ALGAE AT MACPHERSON BAY DURING 1979

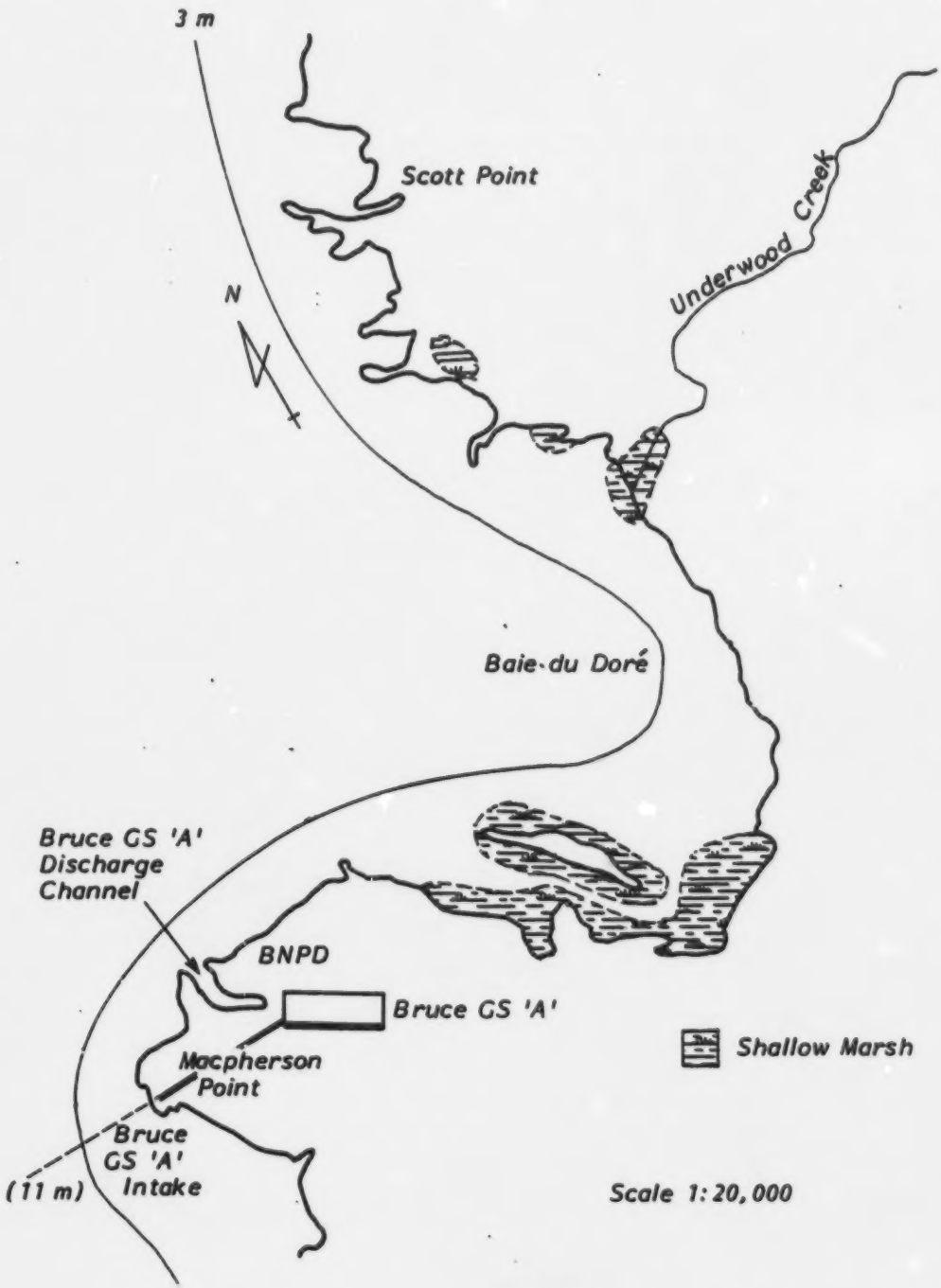

FIGURE 9
MARSH LOCATIONS IN BAIE DU DORÉ

Macrophyte biomass was substantially higher at the deeper (>37 cm) sampling points, and approximately tripled from June 19 to August 25 in both shallow and deep samples (OHRD Report No 82-107-K). A mean total standing crop of 272 g/m^2, obtained in deeper water in August, is probably at or near the maximum biomass attained in the marsh. Emergent bulrushes *(Scirpus* sp) generally constituted greater than 75% of the biomass on each sampling occasion. Total biomass (g/m^2) in the shallow zone during July was within the range reported by Fahselt and Maun (1980) for the smaller marshes occurring further north in Baie du Dore in July, 1978. However, dominance in their study areas was shared between the bulrushes *(Scirpus americanus)* and the alga, *Chara* sp. The latter formed only a minor component of the biomass of some of the samples in 1979.

The maximum biomass recorded for a single species was 242 g/m^2, and was attained by *Scirpus* sp growing in deep water (45 cm) in August. It was concluded that the Baie du Dore marsh area is low to moderately productive compared to other rush and sedge dominated wetlands (OHRD Report No 82-107-K).

4.2.3 Phytoplankton

A. Species Composition and Biomass

Monthly samples collected within the study area (see Figure 2) between May and October of 1979 and 1980 indicated that the Bacillariophyta (diatoms) dominated the phytoplankton (in terms of biomass) on all 12 sampling occasions (OHRD Report Nos 82-107-K and 82-182-K). This result is consistent with that of Munawar and Munawar (1973, in Vollenweider et al 1974), who found that diatoms were the dominant phytoplankton group at a mid lake sampling station in Lake Huron between April and December.

The diatoms made up an estimated 55 to 93% of the total phytoplankton biomass on the 1979 sampling occasions and from 39 to 98% on the 1980 sampling occasions. The proportion of diatom biomass to total phytoplankton biomass was higher from May to July than from August to October and was lowest in October of both years when the Cyanophyta (blue-green algae) gained prominence (OHRD Report Nos 82-107-K and 82-182-K). The blue-green algae made up approximately 30 to 55% of the biomass in October of 1979 and 1980, respectively. The Chlorophyta (green algae) were more prominent in August of both years than in any of the other months.

Phytoplankton samples collected in the BNPD study area from 1973 to 1978 indicated that the algae were dominated by the diatoms in the spring, summer and fall of each year except 1975, in

which year the chlorophytes dominated in the fall (OHRD Report Nos 74-449-H, 75-323-H, 76-343-K, 77-167-K, 78-395-K, and 80-43-K).

Highest mean total phytoplankton biomass for the study area was estimated for May in 1979 (2011 mg/m^3, Table 5) and for June in 1980 (1410 mg/m^3, Table 5). In both years phytoplankton biomass was low from August to October with lowest biomass estimates obtained for August (225 and 258 mg/m^3 in 1979 and 1980, respectively). The total biomass estimates were comparable to the estimates reported by Munawar and Munawar (1973, in Vollenweider et al 1974) of 300 to 1700 mg/m^3.

The diatoms *Rhizosolenia* and *Tabellaria fenestrata* were the most important taxa present in May, June and July of both years (Table 5). *Tabellaria* remained prominent for the rest of the sampling season. *Rhizosolenia* occurred in low densities in August of 1980 and was absent from the 1979 August samples. A group of unidentified Pennales (diatoms) were also prominent on most sampling occasions. *Dinobryon sociale* was the main taxon present in September of 1979 and August of 1980, and was the only member of the Chrysophyta (golden algae) identified in both years. Prominent green algae in the study area were *Cosmarium* and *Pediastrum*. In 1979 the former was present in June, August and September and the latter was present in May and from August to October. *Cosmarium* was present on all sampling dates in 1980 and *Pediastrum* was present from August through October of 1980. The chlorophyte *Zygnema*, which made up 27% of the algal biomass in the 1979 August samples (OHRD Report No 82-107-K), is not a planktonic taxon but an attached alga and its occurrence in the water column was therefore incidental. *Chroococcus* was the main cyanophyte (blue-green alga) present in the study area and was the dominant phytoplankton present in October of 1979 and third most abundant taxon present in October of 1980. Its presence was limited to October in 1979 but was found from July through October in 1980 (Table 5). *Rhodomonas minuta* and *Cryptomonas* were the main pyrrophytes (flagellates) found. *R. minuta* was present throughout the 1979 and 1980 sampling seasons and *Cryptomonas* was present on all sampling occasions except in June of 1979 (OHRD Report Nos 82-107-K and 83-182-K).

B. Spatial Distribution

Monthly sampling at the six lake locations and the two forebays from May through October in 1979 and 1980 did not reveal any consistent spatial trends in the density distributions of the phytoplankton between sampling occasions or between taxa on individual dates (OHRD Report Nos 82-107-K and 82-182-K). Similarly phytoplankton samples collected at grid locations (Figure 2) on June 6-7, August 23, and October 4, 1979, did not

TABLE 5

MEAN DENSITIES (mg/m^3) OF MAIN PHYTOPLANKTON TAXA FOUND IN THE BNPD STUDY AREA, MAY TO OCTOBER 1979 AND 1980

Taxa	1979						
	Sampling Dates						
	May 29	June 6-7	July 11	Aug 23	Sept 18	Oct 14	Mean May-Oct
Rhizosolenia sp	859	606	241	0	43	11	293
Tabellaria fenestrata	404	706	104	90	32	44	230
Unidentified Pennales	137	228	8	15	41	14	74
Stephanodiscus niagarae	296	0	0	6	0	0	50
Diatoma sp	40	209	6	4	1	<1	44
Melosira granulata	135	78	0	0	5	2	37
Dinobyron sociale	28	11	24	4	47	21	36
Fragilaria crotonensis	28	19	3	14	18	12	16
Asterionella gracillima	20	17	13	4	16	8	13
Chroococcus sp	0	0	0	0	0	65	11
Zygnema sp	0	0	0	60	0	0	10
Rhodomonas minuta	17	11	<1	29	15	8	14
Total Biomass all taxa (Range across locations)	2011 (854-3836)	1899 (434-7477)	408 (135-750)	226 (25-909)	324 (247-562)	233 (109-353)	850

Taxa	1980						
	Sampling Dates						
	May 13	June 26	July 15	Aug 13	Sept 22	Oct 23	Mean May-Oct
Rhizosolenia sp	193	567	185	3	36	10	166
Tabellaria fenestrata	248	407	115	23	97	64	159
Unidentified Pennales	27	108	105	73	94	37	74
Dinobyron sociale	14	106	83	31	13	8	43
Melosira granulata	149	36	17	0	5	1	35
Asterionella gracillima	37	87	33	2	3	9	29
Stephanodiscus niagarae	18	1	6	24	24	19	15
Fragilaria crotonensis	0	0	3	3	38	38	14
Chroococcus sp	22	6	2	1	10	31	12
Rhodomonas minuta	16	26	17	4	2	1	11
Diatoma sp	7	3	6	8	11	21	9
Cosmarium sp	3	7	<1	26	4	4	7
Total Biomass all taxa (Range across locations)	771 (319-1016)	1410 (748-1896)	608 (449-720)	258 (35-574)	393 (190-495)	283 (142-377)	621

NB - means include all sampling locations including forebays

reveal any obvious trends in phytoplankton distribution. However, on June 6-7, 1979 substantially higher phytoplankton biomass was found at the most inshore Baie du Dore location (OHRD Report No 82-107-K).

Phytoplankton density distribution in the study area did not appear to be directly related to surface water temperature (OHRD Report Nos 82-107-K and 82-182-K).

In 1980 five replicate samples were taken at Baie du Dore (3 m depth) and Gunn Point (7 m depth) in June, August and October. For the ten most abundant taxa present in the replicate samples the standard deviations of the densities calculated for each replicate ranged from 0.1 to 224% of the mean. The large variation in density estimates between replicate samples identifies the difficulty in detecting spatial differences in phytoplankton biomass.

4.2.4 Zooplankton

A. Species Composition and Biomass

Rotifers

In 1979 the rotifers were numerically dominated by *Synchaeta* spp from May through September (Table 6). *Synchaeta* species identified in 1979 samples were *Synchaeta pectinata* and *S. oblonga*. In 1980 the rotifers were dominated by *Notholca squamula* in May and codominated by *Polyarthra* and *Synchaeta* in June. *Asplanchna* was the most abundant taxon present in July of 1980, *Keratella cochlearis* in August and *Polyarthra* in September and October (Table 6).

Most of the main rotifers identified in the study area in 1979 and 1980 were among those found to be common in the open areas of Lake Huron by Nauwerck (1978). These forms included *Kellicottia, Notholca, Synchaeta, Polyarthra, Conochilus* and *Keratella cochlearis*. In biological surveys conducted in the BNPD study area from 1973-1977 (OHRD Report Nos 74-449-H, 75-323-H, 76-343-K, 77-167-K and 78-395-K), *Keratella (cochlearis)* was the main rotifer occurring in the study area. In 1977 (OHRD Report No 78-395-K) *Synchaeta* gained prominence although *Keratella* was still the most abundant rotifer found, and in 1978 (OHRD Report No 80-43-K) *Synchaeta* was the main rotifer present.

Most of the rotifers collected in the study area in 1979 and 1980, including *Keratella cochlearis, Synchaeta* spp, *Notholca squamula, Conochilus unicornis* and *Gastropus*, were found by Nauwerck (1978) to have an affinity towards oligotrophic

TABLE 6

MEAN DENSITIES (No x $10^3/m^3$) OF THE MAIN ROTIFERS
FOUND IN THE BNPD STUDY AREA, MAY TO OCTOBER 1979 AND 1980

Taxa	1979					
	May 29	June 6-7	July 11	Aug 23	Sept 18	Oct 14
Keratella cochlearis	1.0	0.7	13.0	7.0	3.3	7.0
Synchaeta spp	5.3	4.2	18.9	10.5	3.4	0.9
Conochilus unicornis	<0.1	0.0	16.7	1.8	<0.1	0.5
Polyarthra spp	0.3	1.1	3.3	6.3	2.4	6.3
Notholca squamula	2.9	1.6	<0.1	0.3	<0.1	0.0
Notholca foliacea	0.7	2.2	0.0	<0.1	<0.1	0.0
Kellicottia longispina	0.3	0.3	1.8	1.0	0.2	0.5
Total Number of Rotifers	10.7	12.9	50.2	30.7	12.4	17.8
	1980					
	May 13	June 26	July 15	Aug 13	Sept 22	Oct 23
Polyarthra spp	0.2	2.5	6.0	2.3	4.2	4.6
Keratella cochlearis	0.2	1.5	5.9	4.9	2.0	1.1
Asplanchna spp	<0.1	0.5	19.2	1.2	1.8	0.1
Synchaeta spp	2.0	2.5	1.4	0.4	0.4	0.4
Ploesoma spp	<0.1	1.1	6.2	1.8	0.9	<0.1
Gastropus spp	0.1	0.3	1.2	2.4	1.0	0.5
Notholca squamula	2.2	0.1	<0.1	<0.1	<0.1	0.0
Total Number of Rotifers	6.8	9.8	43.9	15.8	11.6	7.2

waters. The occurrence of several rotifer species which have an affinity for cold, oligotrophic conditions is consistent with the current classification of Lake Huron as an oligotrophic lake (see Section 4.1.5).

In both 1979 and 1980 lowest total rotifer densities were estimated for May (10 664 and 6 800/m^3, respectively) and highest total densities were estimated for July (50 181 and 439 000/m^3, respectively) (Table 6). The relatively low concentrations of rotifers found in the study area compared to those found in surveys similar to the present one conducted in Lake Ontario at Darlington (OHRD Report No 80-387-K) and at Pickering GS (OHRD Report Nos 80-226-K, 82-460-K, and 83-193-K) appears to be typical of Lake Huron.

Crustacean Zooplankton

The calanoid copepods dominated the crustacean zooplankton in the BNPD study area on all sampling occasions in 1979 and 1980 (Table 7).

In 1979, the calanoid nauplii (larvae) made up the largest portions of the total crustacean zooplankton numbers from May through September and were succeeded by the calanoid copepodites (juveniles) in October. The adult calanoid copepods consisted mainly of *Diaptomus minutus* in all months except June when *D. ashlandi* adults were more abundant. In 1980 the calanoid nauplii made up the largest portions of the total numbers from May through August and were followed by the cladoceran, *Bosmina longirostris* in September, and *D. minutus* adults in October. In 1980, *D. oregonensis* adults were the most abundant adult calanoid copepods present in all months except July when *D. ashlandi* adults were more abundant (Table 7).

It was assumed that a main portion of the total numbers of calanoid copepod nauplii and copepodites belonged to the species to which a majority of the adults belonged. Therefore, it appears that *D. minutus* was the major calanoid copepod present in 1979 while *D. oregonensis* was the main calanoid copepod species present in 1980. The two species were prominent in both years. Other calanoid copepods found in the samples were *D. ashlandi* and *D. sicilis*. *Eurytemora affinis* was found in the 1979 samples and *D. siciloides* was found in the 1980 samples. The occurrence of these two taxa was sparse and therefore absence from one year's samples does not necessarily have significance.

In addition to *Diacyclops bicuspidatus thomasi*, other cyclopoid copepods found in the 1979 samples were *Tropocyclops prasinus* and *Mesocyclops edax*. These two copepods were found in very low numbers and this is probably why they were not found in the 1980

TABLE 7

MEAN DENSITIES (No x $10^3/m^3$) OF THE MAIN CRUSTACEAN ZOOPLANKTON FOUND IN THE BNPD STUDY AREA, MAY TO OCTOBER 1979 AND 1980

Taxa	1979					
	May 29	June 6-7	July 11	Aug 23	Sept 18	Oct 14
Bosmina longirostris	0.07	0.47	0.38	0.66	0.04	0.10
Daphnia galeata mendotae	<0.01	0.00	0.02	1.17	<0.01	0.17
Diaptomus minutus (adults)	0.04	0.07	0.07	1.15	<0.01	0.19
Diaptomus ashlandi (adults)	<0.01	0.12	<0.01	0.00	0.00	0.00
Calanoid copepodites (Juvenile)	0.38	0.67	0.35	5.68	0.26	3.05
Calanoid nauplii	4.00	3.67	20.94	7.98	1.35	2.23
Diacyclops bicuspidatus thomasi (CI-CII)	0.10	0.17	0.25	2.63	0.15	2.35
Cyclopoid nauplii	0.16	0.33	5.23	0.94	0.18	0.49
Total Number of Crustacean Zooplankton	4.85	5.10	37.30	21.10	2.03	8.84
Taxa	1980					
	May 13	June 26	July 15	Aug 13	Sept 22	Oct 23
Bosmina longirostris	<0.1	0.7	3.2	2.7	1.5	2.7
Daphnia galeata mendotae	0.0	<0.1	0.0	0.8	<0.1	0.6
Diaptomus minutus	0.1	0.3	0.1	1.0	0.2	0.3
Diaptomus ashlandi	0.3	<0.1	1.5	0.6	<0.1	<0.1
Diaptomus oregonensis	0.3	0.5	0.3	2.3	0.9	3.5
Calanoid copepodites	<0.1	0.1	0.5	0.5	0.1	0.2
Calanoid nauplii	5.1	2.2	5.3	4.6	1.2	2.1
Diacyclops bicuspidatus thomasi (I-VI)	0.3	0.5	2.3	2.5	1.1	2.8
Cyclopoid nauplii	1.6	0.9	7.8	2.9	0.9	1.0
Total Number of Crustacean Zooplankton	7.8	5.2	21.0	18.4	6.8	13.5

samples. *D. bicuspidatus thomasi* was the only cyclopoid copepod found in the 1980 samples (Table 7).

The main cladoceran present in the study area in both years was *B. longirostris* followed by *Daphnia geleata mendotae* and *Eubosmina coregoni*. *Polyphemus* and *Daphnia retrocurva* were found in low numbers in both years. The cladocerans were most abundant in July-August (Table 7).

In yearly biological surveys conducted in the study area from 1973 through 1978 (OHRD Report Nos 74-449-H, 75-323-H, 76-343-K, 77-167-K, 78-395-K, and 80-43-K) the calanoid copepods were found to be the most abundant crustacean zooplankton. In 1975, 1976, 1977, and 1978, when the calanoid copepods were speciated, *D. minutus* was identified as the main species. *B. longirostris* was identified as the main cladoceran present in the study area in the 1973-1978 surveys.

The high relative aburdances of the calanoid copepods is typical for Lake Huron and was also reported by Watson and Carpenter (1974). All the calanoid copepod species found in our study area were on Watson and Carpenter's (1974) list of crustacean zooplankton for Lake Huron. Watson and Carpenter (1974) also found *D. bicuspidatus thomasi* to be the main cyclopoid copepod in Lake Huron and *B. longirostris* was found to be one of the most common cladoceran forms in Lake Huron while *D. galeata mendotae* was one of the more common daphnids.

In both 1979 and 1980 highest abundance of crustacean zooplankton were found in July (21 000 and 37 300/m^3). Lowest numbers were estimated for September in 1979 (2000/m^3) and June in 1980 (5200/m^3). Numbers found in September of 1980 were also relatively low (5800/m^3). The low densities found in September of both years may be related to upwellings which had occurred in the week previous to the September sampling occasions (OHRD Report Nos 82-107-K and 82-182-K).

B. Distribution of Zooplankton

Longshore Distribution

Monthly samples collected at the six lake locations and two forebays described earlier did not reveal any consistent spatial patterns in the densities of the main rotifers and crustacean zooplankton. On individual dates the distribution patterns between individual taxa were generally not consistent either.

Both the rotifers and crustacean zooplankton were frequently found to be more abundant in the Bruce GS 'A' forebay, a phenomenon which in some cases appeared to be related to the

concentration of the zooplankton at the bottom of the water column (Scott Point, 12 m depth) (see discussion on vertical distribution).

The distribution of the zooplankton could not be directly related to surface water temperature or sampling contour.

Vertical Distribution

The vertical distribution of the zooplankton will determine in part the densities of the zooplankton that are entrained by the condenser cooling system of Bruce GS 'A', since the intake of the station is located at a depth of 11 m.

At the 12 m contour Scott Point sampling location the main zooplankton taxa were found to be stratified on the July and August sampling occasions in both years (OHRD Report Nos 82-107-K and 82-182-K). Highest abundances of zooplankton were often found in the lower half of the water column. For example *K. cochlearis* was present at a surface density of 7,600/m^3 compared to a density of 33,600/m^3 at a depth of 10 m in July, 1979 (OHRD Report No 82-107-K). In May, June, September and October of both years the zooplankton were not noticeably stratified. Thus for the times of year that higher abundances were concentrated in the bottom half of the water column (July and August), Bruce GS 'A' was probably entraining larger numbers of zooplankton than it would have with a surface intake. However, the effect of relocation of zooplankton from the bottom of the water column to the surface waters was not detected in the surface spatial distribution of the zooplankton.

Distribution of Zooplankton Along a Sampling Grid (1979 Only)

Grid sampling transects are indicated in Figure 2.

Although spatial patterns in the density distribution of rotifers were identifed on each of the three occasions that sets of grid samples were collected, the patterns were not consistent between dates (OHRD Report No 82-107-K). Patterns in the density distribution of the crustacean zooplankton were also recognizable on the individual dates. August and October patterns were similar in that higher abundances were estimated for the Baie du Dore transect. The general distribution patterns of the rotifers and crustacean zooplankton on each occasion are described below.

June 6-7

Significantly ($F = 3.63$, $P < 0.005$) higher numbers of rotifers occurred along the Baie du Dore transect (M) (mean = 36,500/m^3) than along the remaining transects in 1979 (OHRD Report No 82-107-K). Highest densities of rotifers along the the Baie du Dore transect (92,000/m^3) were found at the most inshore location where phytoplankton biomass was also found to be exceptionally higher (OHRD Report No 82-107-K). The more abundant rotifers found at Baie du Dore in June, 1979 were *Notholca foliacea*, *Trichotria tetractis* and *Polyarthra vulgaris*. The crustacean zooplankton densities along Transects E, I and K (Figure 2) were found to be significantly lower ($F = 4.22$, $P < 0.01$; OHRD Report No 82-107-K) than along the remaining transects.

August 23

Rotifers were found in significantly higher densities ($F = 12.77$, $P < 0.01$) on transects north of the Bruce GS 'A' discharge (A to M) than along the remaining transects (OHRD Report No 82-107-K). The main rotifers present were *S. pectinata* and *P. dolichoptera*. Among depth contours significantly higher densities ($F = 4.53$; $P = 0.05$) of the crustacean zooplankton were found at the 1.0 m contour while among transects densities were significantly higher ($F = 5.51$, $P < 0.01$) along Transect M at Baie du Dore (OHRD Report No 82-107-K) . The crustacean zooplankton consisted mainly of calanoid copepods.

October 2

Rotifers occurred in significantly higher densities ($F = 2.86$, $P < 0.05$) along the Sand Bay transect (A) than on Transects E, I, K, S and U. Densities along the remaining transects (O and Q) were not significantly different from those estimated along Transect A (OHRD Report No 82-107-K). The main rotifers present were *K. cochlearis* and *P. dolichoptera*. The crustacean zooplankton densities were significantly higher ($F = 6.36$, $P < 0.01$) at Baie du Dore (Transect M) than at all other transects except Transect Q at Macpherson Bay (OHRD Report No 82-107-K).

As in the case of the phytoplankton, five replicate samples of zooplankton were taken at Baie du Dore (3 m depth) and Gunn Point (7 m depth) to obtain an indication of the variation that occurs between replicate samples. For the main zooplankton taxa, the standard deviations ranged from 0.3 to 102% of the means with most (74%) being under 40%. This is substantially lower than the deviations estimated between density estimates of

phytoplankton in replicate samples. Since the difference in the densities of the major taxa between locations were frequently estimated to be greater than five-fold, the spatial differences found probably are indicative of the natural variation in the spatial distribution of the zooplankton in the study area.

4.2.5 Benthic Macroinvertebrates

Benthic macroinvertebrates were sampled in two distinct ways in 1979 and 1981. Vacuum domes were used to sample natural populations of benthic organisms and samples obtained are representative of actual benthic community composition. Consequently vacuum dome samples reflect natural patterns of habitat variability over the study area. Rock cage samplers, by presenting an artificial substrate for colonization, provide a measure of substrate standardization which may facilitate more accurate comparison between samples from different areas. However, rock cages trap organic detritus and algae, forming suitable habitats for benthic organisms which settle or are filtered out from the littoral drift. Therefore rock cages may reflect the formation of benthic assemblages resembling those of natural habitats which are considerably distant from rock cage sampling sites.

Major differences in taxonomic composition were found between rock cage and vacuum dome samples from BNPD. Taxa requiring coarse, stable substrates for feeding attachments *(Cheumatopsyche)*, associated algal or detrital food *(Gammarus, Cricotopus)*, or as a refuge for avoiding displacement *(Gammarus, Hyallela)* were common in rock cage samples but much rarer in vacuum dome collections. *Nais* spp, which may be slow to colonize rock cages, were usually more common in vacuum dome samples.

A. Vacuum Domes

Average density of benthic organisms was 795/m^2 in 1979 and 1266/m^2 in 1981 (OHRD Report Nos 82-107-K and 83-96-K). While *Nais pardalis* was the most common taxon in both years (1979-36%; 1981-16%), the overall increase in density was apparently due to increased numbers and dominance of chironomid (Diptera) taxa. Chironomid density increased from 199 to 532/m^2 between the two years, and the relative importance of this group increased from 25% to 42% of all macroinvertebrates collected. Naididae, the most common oligochaetes, were the most abundant group in 1979 (400/m^2) and represented 51% of the entire collection. The relative importance (36% of total collection) but not density (455/m^2) of the Naididae declined in 1981.

Density of zoobenthos showed some trends with depth; however, these trends varied between years. Highest mean total

densities occurred at the 3 m depth contour (1033/m^2) in 1979, and at the 7 m depth contour in 1981 (1731/m^2). In both years, the Bruce GS 'A' discharge transect was characterized by high mean densities (1979-1170/m^2; 1981-2181/m^2). The BHWP discharge transect (1979) and Transect L (1981) also had high densities. *Nais pardalis* was most abundant along discharge transects in 1979 (BHWP and Bruce GS 'A' discharge transect) and 1981 (Bruce GS 'A' discharge transect). The Bruce GS 'A' intake transect supported high densities of *Nais* spp in 1981. These oligochaetes are usually most common in shallower water and at BNPD *Nais* spp were more abundant at the 3 m depth contour (1979-571/m^2; 1981-630/m^2) than at deeper locations.

Pseudosmittia, a chironomid, was found in greatest abundance along the Scott Point transect (mean = 148/m^2), and Sand Bay and Bruce GS 'A' discharge transects (mean = 117/m^2) in 1979. In 1981 the genus was most common along Transect L (mean = 457/m^2) between the Sand Bay and Scott Point transects, and at the Scott Point (mean = 233/m^2) and Gunn Point (mean = 224/m^2) transects. *Pseudosmittia* was common at all depth contours, with maxima at the 12 m contour in 1979 (mean = 75/m^2) and at the 7 m contour in 1981 (mean = 305/m^2).

Thus the main pattern revealed by vacuum dome sampling was a tendency for *Pseudosmittia* to be more prevalent at transects north of Baie du Dore while *Nais* spp were more abundant at Baie du Dore and at discharge transects. In addition, dominant benthic organisms showed some separation by depth, with *Nais* spp being more prevalent inshore (3 m contour) and *Pseudosmittia* being most abundant at 7 m and 12 m contours.

The Shannon-Weiner diversity index was used to facilitate comparison of faunal diversity between samples in each year. Overall, mean zoobenthic diversity in each year was remarkably similar: 2.33 in 1979 and 2.38 in 1981. Maximum diversity in both years occurred along transects to the north of Baie du Dore: Transect E (see Figure 2) (3.08) followed by Scott Point (3.02) in 1979, and Scott Point (2.88) followed by transect E (2.72) in 1981. Baie du Dore samples had the lowest diversity in both 1979 (1.37) and 1981 (1.12). Diversity was highest at the 12 m (1979) or 7 m (1981) depth contours, and lowest at the 1 m contours in both years.

The distribution of zoobenthic assemblages identified by Mutual Information Analysis in both years was consistent with the spatial distribution described above. In both 1979 and 1981, chironomid-dominated assemblages were most commonly encountered along transects to the north of Baie du Dore, in particular, the Sand Bay and E transects.

Nais-dominated assemblages were most likely to be found along the Bruce GS 'A' intake and discharge and BHWP discharge transects shallower than 7 m depth (OHRD Report Nos 82-107-K and 83-96-K).

In 1979, Discriminant Function Analysis was used to determine whether the zoobenthic assemblages identified were correlated with specific environmental factors, which were depth, per cent algal cover, position relative to the compensation point (2 x secchi depth), particle size, temperature and inorganic and organic sedimentation rates (OHRD Report No 82-107-K). The per cent discriminatory power of each variable in describing the distribution of the zoobenthic groupings was: depth - 26.9%, particle size - 26.0%, temperature - 21.9%, compensation point - 10.5%, inorganic sedimentation rate - 6.6%, algal cover - 5.6%, organic sedimentation rate - 2.4%. Thus it appears that depth, substrate particle size and temperature were the most important variables (of those examined) which determined the distribution of benthic assemblages.

Depth distribution of the main benthic taxa was described previously. In terms of substrate, transects south of Baie du Dore (see Figure 1) were associated with greater proportions of large-sized substrate particles (cobble, boulder and bedrock) (see Section 4.1.2). Casual observations made in 1981 suggested that transects north of Baie du Dore were situated in areas where small-sized substrate particles (pebble, gravel and some cobble) predominated. The existence of small substrate particles facilitates those benthic organisms which cling to the substrate in order to avoid displacement (such as chironomids).

The role of temperature in defining the distribution of benthic organisms at BNPD is not clear. The only spatial pattern observed (in both years) which may have been related to thermal input via the Bruce GS 'A' discharge was the collection of the highest densities of *Nais pardalis* at the 1 m (1979 only), 3 m and 7 m (1979 and 1981) contours of the Bruce GS 'A' discharge transect (OHRD Report Nos 82-107-K and 83-96-K). High densities of *N. pardalis* (>1000/m^2) were also recorded at the BHWP discharge (3 m) and Douglas Point GS discharge (7 m) transects in 1979 (OHRD Report No 82-107-K). The proliferation of *N. pardalis* in the discharge areas may be the result of heat enrichment since naids reproduce primarily by asexual means (Learner, 1978).

B. Rock Cages

Mean benthic density (No. of invertebrates per rock cage) was 75 (range 2 - 104) in 1979 and 102 (range 0 - 900) in 1981. The number of invertebrate orders represented was 13 (1979) and 12 (1981). Most orders were present in similar proportions in

each year, but oligochaetes and dipterans exchanged position in the dominance hierarchy (Table 8). Diptera, the most abundant order in 1979 (33%) decreased to 20% in 1981, and oligochaetes increased from 19% to 30% over the same period.

TABLE 8

REPRESENTATION OF COMMON BENTHIC INVERTEBRATE ORDERS AT BNPD, 1979 AND 1981 (ROCK CAGE COLLECTIONS)

Order	1979 (%)	1981 (%)	$\bar{X}$ ± SD
Oligochaeta	19	30	24.5 ± 7.8
Diptera	33	20	26.5 ± 9.2
Amphipoda	16	19	17.5 ± 2.1
Ephemeroptera	12	10	11.0 ± 1.4
Trichoptera	10	9	9.5 ± 0.7
Gastropoda	5	9	7.0 ± 2.8

Although benthic density and taxonomic composition changed noticeably between 1979 and 1981, some general trends persisted. In both years, density of benthic macroinvertebrates (mean no invertebrates per rock cage per transect) was highest in the shallow waters of Baie du Dore, and lowest densties were collected along the Bruce GS 'A' intake transect. Sand Bay, second most productive transect in 1979, was replaced by Bruce GS 'A' discharge transect in 1981. The BHWP discharge, Scott Point, and Macpherson Bay transects were also characterized by higher benthic densities than were found at Sand Bay. In 1979, concentrations of *Gammarus*, *Orthocladius*, and *Cheumatopsyche* commonly determined the transects where high standing crops of macroinvertebrates occurred, while in 1981, *Nais pardalis*, *N. variabilis*, *Cheumatopsyche*, and *Gammarus* were found in high local concentrations. Highest mean densities were found in the shallowest samples; density decreased with depth in both years from the 3 m to 12 m depth contours. Density was lowest in spring, and was highest in July-August of both 1979 and 1981 (OHRD Report Nos 82-107-K and 83-96-K).

Shannon-Weiner diversity (evenness and richness) was generally highest at the 7 m depth contour in both years (1979 = 3.35; 1981 = 3.27), followed by the 3 m depth contour (1979 = 3.31; 1981 = 3.08). The 12 m depth contour was associated with the least diverse grouping of zoobenthos. Total mean diversity was

3.27 in 1979 and 3.04 in 1981. Longshore trends in diversity were more variable between years than were depth trends. Gunn Point transect displayed the highest mean diversity in both 1979 and 1981 (3.50, 3.47 respectively), but Sand Bay transect, with the second highest 1979 diversity (3.41) was second lowest in 1981 (3.04). The Bruce GS 'A' discharge transect displayed the lowest diversity in both years (2.97, 2.84) (OHRD Report Nos 82-107-K and 83-96-K).

Higher numbers of common *Nais* species (*N. pardalis, N. simplex, N. variabilis*) occurred in 1981 than in 1979 rock cage samples. The number of these worms increased 235% between 1979 and 1981. In both years, *Nais* species were abundant in warm, shallow waters such as Baie du Dore, and the Bruce GS 'A', BHWP, and Douglas Point GS discharge areas. The enormous increase in naid abundance in rock cages was due primarily to the high number of *N. pardalis* (1,776/rock cage) found at the 3 m contour of the Bruce GS 'A' discharge transect in 1981 (OHRD Report No 83-96-K). This finding agrees well with the naid distribution pattern indicated by vacuum dome samples (see above). The abundance of *Nais* species was low at the beginning (May) and end (October) of the sampling season and reached highest values in July (1981) or August (1979), probably as a result of increased asexual reproduction during these warm months.

Amphipods of the genus *Gammarus* (*G. fasciatus* and *Gammarus* spp.) were common benthic macroinvertebrates in both years at BNPD. These detritus-shredding invertebrates (Kaushik and Hynes 1971) were locally concentrated at the 3 m and 7 m contours of the Baie du Dore (particularly in 1979) and Bruce GS 'A' discharge transects, where autochthonous macrophyte detritus may be common (see Section 4.2.1, Figure 8 and Section 4.2.2, Figure 9). Recruitment of *Gammarus* over mid-summer (July-August) due to seasonal timing of reproduction resulted in the high numbers observed in July of 1979 and 1981. The association of *Gammarus* with detrital concentrations is also reflected in their depth distribution: numbers were highest and similar in both years along the 3 m depth contour (80%, 74% of all gammarids collected in 1979 and 1981, respectively). Representation along the 7 m and 12 m depth contours was approximately equal in each year (OHRD Report Nos 82-107-K and 83-96-K).

The caddisfly *Cheumatopsyche* sp, which feeds on suspended particulate material trapped in its net (Wiggins 1977), occurred in large numbers in both years along the 3 m depth contour (99% of all *Cheumatopsyche* collected), where currents or wave action keep the water in motion. Areas along the exposed shore of Lake Huron are subject to considerable wave and current exposure: Sand Bay and Scott Point both supported high densities of *Cheumatopsyche* in 1979 (means per rock cage = 36.5 and 17.0, respectively) and 1981 (23.9 and 21.5). A noticeable difference in *Cheumatopsyche* abundance occurred between years in Baie du Dore: an average six individuals (per rock cage) in 1979 and a mean of 166 in 1981. Although particulate detritus (from decomposition of macrophytes, algae, and emergent vegetation) is probably more common in Baie du Dore than elsewhere, water currents to carry the particulate food are likely of lower velocity than those found along the exposed shore. *Cheumatopsyche* often forms high density aggregations (Hynes, 1970), and the high numbers observed in 1981 (at the 3 m contour of Sand Bay, Scott Point and Baie du Dore transects) were apparently due to recruitment in August, probably from egg masses deposited upon the rock cages. The rock cages may form "islands" of suitable substrate; in deep water streams (and possibly in lakes), hydropsychid abundance may be limited more by substrate suitability than by food resource limitation (Benke and Wallace, 1980).

Hyallela azteca, the only other common amphipod found at BNPD in rock cage samples, appears to be a habitat generalist. It was present along all transects in similar numbers (2 to 23 individuals per rock cage). In addition, *H. azteca* appears less selective of any particular depth than other common invertebrate taxa. Although the 3 m and 7 m depth contours supported the highest proportions of this amphipod (1979 - 3 m = 28%, 7 m = 44%; 1981 - 3 m = 59%, 7 m = 29%), some individuals (27% and 12% of total) occurred at the 12 m depth contour in 1979 and 1981, respectively (OHRD Report Nos 82-107-K and 83-96-K).

Common dipteran taxa in both years were of the family Chironomidae. Seasonal abundance was lower on average in 1981, but highest numbers were recorded in mid-summer of both years (July-August) as new individuals were recruited to the populations. Common chironomids in 1979 were *Orthocladius nigritum* (highest mean number at Scott Point = 40.5 per rock cage), and *Cricotopus* T_2 (highest mean number at Bruce GS 'A' discharge = 23.0). These taxa were not common in 1981 in rock cage samples: *Cladopelma* spp were abundant along the Bruce GS 'A' discharge transect (mean = 108/rock cage), and *Cricotopus [isocladius]* occurred in fairly high numbers (mean = 29/rock cage) in Baie du Dore samples. Little is known of the comparative ecology of these species; most ecological information is generalized at the

generic level (Merritt and Cummins, 1978). *Orthocladius* species are often associated with erosional areas of lake littoral zones (Merritt & Cummins 1978), and strong longshore currents are characteristic of the exposed shore in the area of BNPD (Ontario Hydro Design and Development Division Report No 83336). *Cladopelma* species, found only at the 3 m contour of Bruce GS 'A' discharge transect in early July, 1981 (mean = 432/rock cage), are usually found in the depositional areas of littoral zones (Merritt & Cummins 1978). Substrate analysis of this area (Section 4.1.2) indicated that the bottom was dominated by cobble-sized particles (64-256 mm) and bedrock so the occurrence of this genus remains unexplained. It is noteworthy that the only other benthic organism for which high abundance in rock cages was recorded at the 3 m contour of the Bruce GS 'A' discharge transect was *Nais pardalis*.

4.2.6 Fish Community

A. Juvenile and Adult Fish

Species Composition

Species richness was similar at BNPD in 1979 (42 species) and 1980 (41 species) but differed in 1981 (48 species). Thirty-three (33) fish species were common to catches of all three sampling years, indicating a substantial consistency in catch composition between years. Six (6) species which were captured in 1981 but not in 1979 or 1980 were quillback *(Carpiodes cyprinus)*, channel darter *(Percina copelandi)*, northern redbelly dace *(Chrosomus eos)*, bowfin *(Amia calva)*, lake sturgeon *(Acipenser fulvescens)* and pink salmon *(Oncorhynchus gorbuscha)*. These species were not captured in any discharge area at BNPD and their presence is not considered abnormal.

A quantitative way of measuring the temporal similarity between fish communities is to use a similarity index. Morisita's index of similarity (MI) was used to monitor annual species composition variation since it is sensitive to changes in relative abundance and is based on a comparison of dominant species common to a given area on different sampling occasions (Russo, 1982). This index, which has extreme values of 0 (dissimilarity) and 1 (similarity), takes the form:

$$MI = \frac{2 \sum_{i=1}^{K} n_i(t_1) n_i(t_2)}{[b t_1) + b(t_2)] N(t_1) N(t_2)}$$

where K is species in common, $n_i(t_n)$ is the number of fish of species i at time t_n, $N(t_n)$ is the total number of fish counted at time t_n, and

$$b(t_n) = \frac{2 \sum_{i=1}^{S} n_i(n_i-1)}{N(N-1)}$$

where S is the total number of species at time t_n. Morisita's index was calculated for combined May, June and July gill net catch data at the Bruce GS 'A' discharge location.

Values of Morisita's index were 0.99 and 0.90 for the 1979-80 and 1980-81 periods, respectively. These results indicate a high degree of similarity between annual gill net catches and support the general conclusion that fish species composition at BNPD remained stable over the three-year study period.

Abundance and Distribution

Total fish catch was 14,631 in 1979, 13,076 in 1980, and 11,874 in 1981 (Table 9). Fish species which occurred in moderate to high abundance over the three-year study period, and which are discussed below, include alewife *(Alosa pseudoharengus)*, spottail shiner *(Notropis hudsonius)*, yellow perch *(Perca flavescens)*, bluntnose minnow *(Pimephales notatus)*, longnose sucker *(Catostomus catostomus)*, white sucker *(Catostomus commersoni)*, gizzard shad *(Dorosoma cepedianum)*, brown bullhead *(Ictalurus nebulosus)*, rock bass *(Ambloplites rupestris)*, smallmouth bass *(Micropterus dolomieui)*, walleye *(Stizostedion vitreum)*, channel catfish *(Ictalurus punctatus)*, round whitefish *(Prosopium cylindraceum)* and lake chub *(Couesius plumbeus)*.

Alewife

Alewife was the most abundant fish species collected in gill and trap nets in each survey year with the exception of the 1980 trap net catch (Table 9). Highest alewife abundance in gill nets generally occurred in May of each year, but sometimes occurred in June, particularly at the three discharge sampling locations in 1979 and 1980 (Table 10). High gill net catches of alewife at Bruce GS 'A' discharge in July, 1979, Gunn Point in August, 1980, and Douglas Point GS discharge in August, 1981 are exceptions to the normal spring peak for this species at the

TABLE 9

SUMMARY OF FISH CATCH DATA FOR MAJOR SPECIES COLLECTED AT BNPD (1979-1981)

Fish Species	1979			1980			1981		
	Gill Net	Trap Net	Beach Seine	Gill Net	Trap Net	Beach Seine	Gill Net	Trap Net	Beach Seine
Alewife	2732	2501	2764	2990	81	746	1872	670	144
Longnose Sucker	488	255	0	421	180	10	735	582	0
White Sucker	482	229	0	538	183	4	519	527	24
Gizzard Shad	166	0	0	381	0	2	217	2	54
Brown Bullhead	0	209	0	35	44	0	22	208	0
Lake Chub	317	61	0	261	14	6	178	7	9
Yellow Perch	187	33	22	184	33	966	118	32	1
Rock Bass	0	108	120	33	73	0	32	164	0
Channel Catfish	14	0	0	89	6	0	118	6	0
Smallmouth Bass	0	33	0	20	13	17	19	85	3
Walleye	16	0	0	57	0	0	91	0	0
Round Whitefish	42	0	0	54	0	0	102	1	0
Spottail Shiner	0	0	2067	124	0	4222	1	0	3085
Bluntnose Minnow	0	0	981	0	0	456	0	0	1198
Sub Totals* by Gear Type	4650	3455	6526	5419	688	6969	4198	2335	5341
Total Annual Catch*	14,631			13,076			11,874		

* Includes all species captured

TABLE 10

CATCH PER UNIT EFFORT OF ALEWIFE AND GIZZARD SHAD
IN GILL NETS AT BNPD, 1979-1981

	Location	Sand Bay			Scott Point			Baie du Dore			Bruce 'A' GS Discharge			Macpherson Bay			BHWP Discharge			Douglas Point GS Discharge			Gunn Point		
	Year	79	80	81	79	80	81	79	80	81	79	80	81	79	80	81	79	80	81	79	80	81	79	80	81
Alewife	May	293.0	36.0	43.0	110.0	179.0	161.0	344.0	243.0	336.0	165.0	7.0	95.0	89.0	7.0	136.0	157.0	3.0	196.0	2.0	135.0	23.0	363.0	69.0	1.0
	June	22.0	74.0	78.0	19.0	127.0	8.0	32.0	134.0	12.0	19.0	218.0	8.0	260.0	200.0	3.0	143.0	335.0	4.0	85.0	134.0	162.0	29.0	45.0	50.0
	July	52.0	52.0	3.0	7.0	10.0	33.0	10.0	0.0	11.0	277.0	0.0	30.0	93.0	6.0	36.0	85.0	77.0	140.0	8.0	5.0	37.0	25.0	0.0	29.0
	August	2.0	5.0	1.0	1.0	15.0	2.0	6.0	0.0	0.0	0.0	1.0	0.0	1.0	24.0	6.0	0.0	50.0	2.0	0.0	10.0	161.0	2.0	224.0	31.0
	September	14.0	9.0	0.0	4.0	19.0	1.0	2.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	October	2.0	0.0	0.0	5.0	5.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Gizzard Shad	May	2.0	0.0	1.0	0.0	0.0	0.0	26.0	90.0	1.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	June	0.0	0.0	0.0	0.0	0.0	0.0	9.0	49.0	47.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
	July	0.0	0.0	0.0	0.0	39.0	7.0	9.0	53.0	53.0	0.0	2.0	1.0	0.0	2.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	1.0	0.0
	August	0.0	9.0	3.0	0.0	0.0	9.0	9.0	26.0	22.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	September	3.0	11.0	5.0	4.0	4.0	15.0	1.0	4.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	4.0
	October	1.0	11.0	2.0	7.0	1.0	5.0	0.0	72.0	18.0	5.0	2.0	4.0	3.0	0.0	0.0	2.0	0.0	5.0	17.0	0.0	0.0	68.0	0.0	1.0

BNPD site. The former alewife catch was possibly indicative of fish arriving inshore to spawn later than usual while the latter two alewife catches probably represented fish moving offshore after spawning in inshore waters. Three-way analysis of variance (ANOVA) (Snedecor and Cochran, 1980) indicated that gill net catches were significantly different ($P < 0.05$) according to the month of sampling, but not for sampling transect or year (Table 11). The location x month and location x year interaction terms were significant ($P < 0.05$), Table 11) suggesting that the seasonal appearance of alewife inshore was not consistent either along the BNPD shoreline or from year to year.

Shifts in the duration or timing of the annual alewife inshore spawning migration could alter apparent alewife inshore abundance. Changes in the timing of the maximum alewife catch in gill nets between 1980 and 1981 (all sites except Sand Bay and Gunn Point) may indicate that such a phenomenon occurred (Table 10).

The total trap net catch of alewife was 2501 in 1979 and 81 in 1980 (Table 9). The highest trap net catch among locations in 1979 occurred at Baie du Dore (CUE = 48). Maximum alewife catches were recorded at most locations in May, 1979 (CUE = 76) (OHRD Report No 82-107-K). Only small, sporadic trap net catches of alewife occurred in 1980 (CUE range = 0 - 17) (OHRD Report No 82-182-K). Highest trap net catches of alewife occurred in May or June in 1981, with the maximum catch recorded at Sand Bay (CUE = 30) (OHRD Report No 83-96-K). These differences in trap net catches of alewife between years, compared with the relatively consistent gill net catches, perhaps reflect the fact that the latter gear type is usually more effective for sampling adult alewife. Consequently only gill net catches can reflect real trends in adult alewife abundance.

The overall beach seine catch of alewife varied considerably over the three-year period (Table 9). Alewife which occurred in beach seine hauls were predominantly young-of-the-year fish. In 1979 when the largest alewife catch in beach seines was recorded, greater numbers of alewife were captured at the three northernmost sampling locations, ie Sand Bay, Scott Point and Baie du Dore. Maximum alewife catches generally occurred in August or September in beach seines in 1979 (OHRD Report No 82-107-K). Alewife were also caught in large numbers at the northern end of the study area in August, 1980 (OHRD Report No 82-182-K). Only 144 alewife were caught by beach seine in 1981 (Table 9). The large variation in alewife catch in beach seines precludes the identification of a trend in abundance at BNPD.

TABLE 11

RESULTS OF THREE-WAY ANALYSIS OF VARIANCE FOR SELECTED FISH SPECIES CAPTURED IN GILL NETS AT BNPD (1979-1981)

Species	Values of Calculated F Statistic					
	Single Factor			Interaction Terms		
	Location	Month	Year	Location x Month	Location x Year	Month x Year
Alewife	NS 0.51 [7,144]	** 17.76 [5,144]	NS 1.14 [2,144]	* 1.60 [35,144]	NS 0.64 [14,144]	** 2.93 [10,14]
Longnose Sucker	** 5.13 [7,144]	** 9.01 [5,144]	NS 3.04 [2,144]	NS 1.46 [35,144]	NS 1.07 [14,144]	* 2.16 [10,144]
White Sucker	** 4.56 [7,144]	** 3.38 [5,144]	NS 0.13 [2,144]	** 2.01 [35,144]	NS 0.75 [14,144]	* 2.41 [10,144]
Gizzard Shad	** 13.85 [7,144]	NS 1.50 [5,144]	NS 2.53 [2,144]	NS 1.18 [35,144]	* 3.40 [14,144]	NS 0.91 [10,144]
Channel Catfish	** 5.84 [7,144]	* 3.11 [5,144]	** 5.25 [2,144]	NS 1.23 [35,144]	NS 0.83 [14,144]	** 2.69 [10,144]
Walleye	** 8.91 [7,144]	** 8.21 [5,144]	** 8.86 [2,144]	NS 1.29 [35,144]	NS 0.93 [14,144]	NS 1.38 [10,144]
Round Whitefish	NS 1.49 [7,144]	** 13.78 [5,144]	* 3.78 [2,144]	NS 0.83 [35,144]	NS 0.69 [14,144]	NS 1.59 [10,144]

NS Not Significant
* Significant ($P < 0.05$)
** Significant ($P < 0.01$)

Gizzard Shad

Gizzard shad is a pelagic, herbivorous (as an adult) fish species which moves inshore to spawn during spring and early summer (Scott and Crossman, 1973). Gill net catch data indicate that gizzard shad were significantly ($P < 0.01$, Table 11) more abundant in Baie du Dore than at any other sampling location, regardless of the sampling year (Table 10). Although gizzard shad may utilize Baie du Dore as a spawning area their continued presence in the bay throughout the summer in moderate numbers (22-53 fish per gill net in July and August of 1980 and 1981) suggests that other features of the bay may be important.

Two factors which are likely to influence gizzard shad distribution are temperature and food availability. With respect to temperature, Figure 5 (Section 4.1.4) shows that the Baie du Dore summer water temperature range was about 16 to 25°C in 1981, and was often between 4 to 6°C cooler than Bruce GS 'A' discharge surface waters. Since considerably fewer gizzard shad were captured in Bruce GS 'A' discharge than in Baie du Dore during the summers of 1980 and 1981 (Table 10), it is possible that gizzard shad preferred the summer thermal regime of the latter site over the former in those years. Several researchers have found that during the summer gizzard shad prefer water at 18 to 26°C (at control sites) rather than warmer water associated with generating station discharge channels (Electric Power Research Institute Report EA-1840, 1981).

Gizzard shad may also frequent Baie du Dore to feed. Plankton grid samples obtained in June, 1979 revealed that phytoplankton densities were higher in the bay than at other nearshore sampling points (see Sections 4.2.3).

SCUBA observations and gill net catches made during the fall/winter of 1980/1981 in the Bruce GS 'A' discharge channel as part of a winter fish residency study indicated that over 1 000 gizzard shad were resident in the discharge area (OHRD Report No 81-308-K). Gizzard shad was the most abundant fish species taken in gill nets during the winter residency study, reflecting the preference of this species for warm water during the winter (EPRI, 1981).

Spottail Shiner

Overall catch of spottail shiner in beach seines was lowest in 1979 (2,067 fish) and highest in 1980 (4,222 fish), (Table 9). This substantial difference in catch between years may be partially attributed to the natural variation which is associated with beach seine hauls. The total 1981 catch of spottail shiner in beach seines was 3,085. The inability to obtain May or

September beach seine samples probably influenced the overall spottail shiner catch in 1981.

Maximum abundance of spottail shiner occurred in either July or August of each year (Table 12), corresponding to the spawning period for this species (Scott and Crossman, 1973). Scott Point and Gunn Point transects were associated with very high catches of this cyprinid in 1979 and 1980, respectively. Notably few spottail shiner were seined in Baie du Dore over the three-year sampling period (Table 12).

Bluntnose Minnow

Bluntnose minnow were also captured in beach seines during the study period and demonstrated highest abundance in the summer months at Scott Point and Baie du Dore. However, during 1980 and 1981 the maximum numbers of bluntnose minnow were caught during August, while the maximum catch occurred during September in 1979 (Table 12). This record of late summer abundance (1979) is not anomalous since the habit of spawning on the undersurface of such objects as flat stones and boards at night would reduce vulnerability to capture by seine nets during the normal May to August spawning period (Scott and Crossman, 1973).

Bluntnose minnow were not particularly prevalent at any of the discharge sampling locations, except for a catch per beach seine of 37.5 recorded at Bruce GS 'A' discharge in July, 1979. This catch was still well below the maximum catch per beach seine (168.0) obtained at Scott Point in September, 1979 (Table 12).

Lake Chub

Lake chub is a large minnow which was caught mainly by gill nets in the BNPD nearshore area. Overall catch (in both gill and trap nets) of this species was highest in 1979 and lowest in 1981 (Table 9). The sequential decrease in lake chub abundance over the three-year period may not necessarily reflect the true status of the population near BNPD. Changes in the timing of migration (inshore or offshore) could reduce the number of lake chub caught in gill nets or perhaps shift the temporal peak in inshore abundance.

Maximum catch per gill net usually occurred during the spring (May and June). However, maximum lake chub catches occurred in July (instead of May or June) at two locations in 1980 (Macpherson Bay and Douglas Point GS discharge) and three locations in 1981 (Scott Point, BHWP discharge and Douglas Point GS discharge), raising the possibility that temporal shifts in peak abundance may have occurred in 1980 and 1981 (Table 13).

TABLE 12

CATCH PER UNIT EFFORT OF BLUNTNOSE MINNOW AND SPOTTAIL SHINER IN BEACH SEINES AT BNPD, 1979-1981

	Location	Sand Bay			Scott Point			Baie du Dore			Bruce GS 'A' Discharge			Macpherson Bay			BNP Discharge			Douglas Point GS Discharge			Gunn Point		
	Year	79	80	81	79	80	81	79	80	81	79	80	81	79	80	81	79	80	81	79	80	81	79	80	81
Bluntnose Minnow	May	0.00	0.00	--	5.0	0.00	--	7.50	2.00	--	0.00	0.00	--	0.50	0.00	--	0.50	0.00	--	0.00	0.00	--	0.00	0.00	--
	June	0.00	0.00	0.00	0.00	0.50	5.50	0.50	1.50	2.50	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	July	0.00	0.00	19.00	5.50	0.00	56.50	18.50	16.00	17.00	37.50	0.00	0.00	0.00	0.50	0.00	0.00	0.00	13.00	0.0	0.00	0.00	0.00	0.00	0.00
	August	1.00	5.00	43.50	11.00	142.50	201.50	9.50	43.50	189.00	1.50	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	2.00	0.00	8.00
	September	13.00	0.00	--	168.00	4.50	--	130.00	6.00	--	0.00	0.00	--	0.00	0.50	--	0.00	0.00	--	0.00	0.00	--	0.50	0.00	--
	October	0.00	0.00	0.50	1.00	0.50	0.00	77.00	0.00	41.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
Spottail Shiner	May	0.00	89.50	--	8.00	7.00	--	5.50	0.00	--	0.00	0.00	--	5.00	0.00	--	1.50	0.00	--	0.50	0.00	--	21.50	0.00	--
	June	41.50	86.00	26.00	6.50	4.00	55.00	0.00	0.50	5.00	0.00	18.00	2.00	6.00	29.50	24.00	0.00	6.00	0.00	0.00	0.50	0.00	2.50	4.00	0.00
	July	23.00	0.00	1090.0	659.00	4.50	33.50	0.00	2.50	0.50	31.00	37.00	0.00	19.00	12.00	78.00	0.00	0.00	8.00	0.00	0.50	0.00	0.00	0.50	0.00
	August	49.50	14.50	23.50	9.00	16.50	21.50	0.50	0.00	0.50	1.50	159.50	0.50	0.00	0.00	2.00	0.00	0.00	30.50	0.00	0.00	0.50	0.00	1200.00	106.50
	September	19.00	0.00	--	5.00	5.50	--	0.50	1.00	--	0.00	0.00	--	0.50	65.50	--	0.00	59.50	--	0.00	151.00	--	109.50	10.50	--
	October	0.00	0.00	0.00	5.50	1.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00	127.50	0.00	0.00	0.00	0.00

-- no samples collected due to weather conditions

TABLE 13

CATCH PER UNIT EFFORT OF LAKE CHUB IN GILL NETS AND ROCK BASS IN 1.2 m TRAP NETS AT BNPD, 1979-1981

	Location	Saul Bay			Scott Point			Baie du Dore			Bruce 'A' Discharge			MacPherson Bay			BNP Discharge			Douglas Point Discharge			Gunn Point		
	Year	79.0	80.0	81.0	79.0	80.0	81.0	79.0	80.0	81.0	79.0	80.0	81.0	79.0	80.0	81.0	79.0	80.0	81.0	79.0	80.0	81.0	79.0	80.0	81.0
Lake Chub	May	13.0	67.0	0.0	10.0	15.0	4.0	1.0	0.0	0.0	8.0	0.0	2.0	26.0	1.0	1.0	0.0	5.0	0.0	0.0	0.0	2.0	49.0	18.0	3.0
	June	26.0	6.0	8.0	27.0	32.0	4.0	0.0	0.0	0.0	27.0	8.0	2.0	22.0	1.0	2.0	11.0	7.0	1.0	3.0	6.0	0.0	27.0	17.0	26.0
	July	8.0	1.0	0.0	2.0	0.0	38.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0	13.0	0.0	1.0	0.0	42.0	2.0	26.0	23.0	22.0	0.0	5.0
	August	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	9.0	0.0	4.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	3.0
	September	2.0	3.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	2.0	2.0	0.0	2.0	1.0	2.0	2.0	0.0	0.0
	October	1.0	3.0	0.0	0.0	1.0	0.0	1.0	7.0	3.0	0.0	0.0	0.0	2.0	3.0	1.0	1.0	2.0	2.0	0.0	0.0	0.0	0.0	6.0	4.0
Rock Bass	May	0.00	0.00	0.00	1.50	0.25	0.50	0.00	1.25	8.00	0.25	0.00	0.25	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	June	0.25	0.25	0.00	0.00	0.00	0.00	1.50	8.00	6.00	0.50	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.25	0.00	0.00	0.00	0.00
	July	0.25	0.00	0.50	0.00	0.50	2.00	2.00	1.00	7.00	0.00	0.00	1.00	0.00	0.25	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	August	0.25	0.00	0.00	0.00	0.00	3.50	0.00	0.25	6.00	9.50	3.50	1.25	0.00	1.00	0.50	0.00	5.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00
	September	0.00	--	0.00	0.75	0.0	0.75	1.00	0.75	2.50	8.50	0.0	2.75	0.00	--	0.00	0.00	--	0.75	0.00	--	0.00	0.25	--	1.00
	October	0.00	--	0.00	0.00	--	0.00	0.00	--	0.50	0.50	--	0.00	0.00	--	0.00	0.00	--	0.25	0.00	--	0.00	0.00	--	0.00

-- no sample obtained due to weather conditions

Greater numbers of lake chub were generally taken at Sand Bay, Scott Point and Gunn Point locations than at other sampling locations in each year of study (with the exceptions noted above). Few lake chub appeared to frequent the Baie du Dore area during sampling times (Table 13).

Lake chub normally migrate inshore to spawn in streams during the spring and return to deeper lake waters during the summer (Scott and Crossman, 1973).

It is noteworthy that for May and June (spring) catches combined, Bruce GS 'A' discharge and Macpherson Bay locations were associated with substantially lower catches in 1980 and 1981 than in 1979 (Table 13). Also, no lake chub were caught at the Bruce GS 'A' discharge location after June in each year of sampling. These observations, together with the paucity of lake chub taken at Baie du Dore, may indicate that during their inshore migration lake chub tend to avoid the warmer shoreline areas such as Baie du Dore and Bruce GS 'A' discharge. Numbers of lake chub captured at BHWP and Douglas Point GS discharge locations were low throughout the study period.

Yellow Perch

Numbers of yellow perch captured in the BNPD sampling area were relatively consistent over the three-year period (Table 9). Gill net catches were generally highest at Baie du Dore and Gunn Point in June and July during each year, but high catches were also recorded at Scott Point from July to September, 1980. Yellow perch did not appear to concentrate near the discharge areas during the three-year study period (OHRD Report Nos 82-107-K, 82-182-K and 83-96-K).

Young-of-the-year yellow perch were only captured in large numbers at Sand Bay and Gunn Point locations during August, 1980, when 192 and 768 fish, respectively, were taken in beach seines (OHRD Report No 82-182-K).

Longnose Sucker

Longnose sucker were taken in highest numbers during 1981 when 735 and 582 fish were captured in gill nets and trap nets, respectively (Table 9).

Longnose sucker gill net catches in Baie du Dore and the discharge locations were not substantially altered between sampling years (Table 14). Catch variability in gill nets was statistically significant ($P < 0.05$) according to the month and location but not year of sampling (Table 11). A significant interaction between month and year of sampling ($P < 0.05$,

TABLE 14

CATCH PER UNIT EFFORT OF WHITE SUCKER AND LONGNOSE SUCKER IN GILL NETS AT BNPD, 1979-1981

	Location	Sand Bay			Scott Point			Baie du Dore			Bruce GS 'A' Discharge			Macpherson Bay			BNMP Discharge			Douglas Point GS Discharge			Gunn Point		
	Year	79	80	81	79	80	81	79	80	81	79	80	81	79	80	81	79	80	81	79	80	81	79	80	81
White Sucker	May	8.0	13.0	12.0	11.0	13.0	14.0	34.0	65.0	25.0	5.0	8.0	11.0	8.0	4.0	16.0	0.0	7.0	23.0	1.0	1.0	3.0	9.0	8.0	5.0
	June	29.0	15.0	11.0	30.0	11.0	7.0	37.0	40.0	21.0	26.0	12.0	13.0	5.0	5.0	3.0	18.0	5.0	6.0	6.0	5.0	21.0	18.0	4.0	8.0
	July	6.0	15.0	59.0	12.0	6.0	26.0	28.0	12.0	11.0	4.0	0.0	1.0	10.0	3.0	18.0	9.0	24.0	24.0	10.0	4.0	0.0	9.0	18.0	3.0
	August	10.0	10.0	9.0	8.0	16.0	3.0	6.0	1.0	1.0	0.0	4.0	0.0	3.0	13.0	6.0	3.0	23.0	6.0	1.0	9.0	0.0	9.0	60.0	9.0
	September	3.0	11.0	4.0	11.0	10.0	1.0	3.0	4.0	2.0	3.0	0.0	1.0	6.0	4.0	3.0	12.0	10.0	6.0	4.0	5.0	5.0	29.0	1.0	28.0
	October	3.0	6.0	19.0	11.0	10.0	8.0	2.0	9.0	13.0	1.0	2.0	5.0	13.0	1.0	1.0	4.0	2.0	5.0	0.0	3.0	16.0	4.0	13.0	23.0
Longnose Sucker	May	16.0	32.0	31.0	27.0	29.0	53.0	3.0	0.0	7.0	7.0	2.0	13.0	30.0	2.0	6.0	26.0	55.0	17.0	18.0	6.0	2.0	24.0	27.0	12.0
	June	29.0	28.0	41.0	35.0	25.0	30.0	0.0	0.0	2.0	35.0	2.0	10.0	9.0	9.0	11.0	16.0	13.0	13.0	14.0	7.0	26.0	37.0	6.0	22.0
	July	30.0	1.0	143.0	8.0	5.0	40.0	0.0	0.0	1.0	4.0	0.0	5.0	31.0	13.0	44.0	23.0	11.0	29.0	5.0	20.0	5.0	9.0	3.0	23.0
	August	0.0	10.0	0.0	1.0	9.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	1.0	1.0	14.0	6.0	0.0	4.0	5.0	4.0	17.0	61.0
	September	3.0	5.0	2.0	1.0	5.0	2.0	1.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.0	8.0	1.0	0.0	0.0	0.0	0.0	4.0	0.0	2.0
	October	3.0	8.0	11.0	1.0	2.0	3.0	0.0	0.0	0.0	0.0	1.0	1.0	4.0	1.0	3.0	14.0	3.0	4.0	1.0	7.0	4.0	1.0	19.0	19.0

Table 11) indicates that the month when the maximum longnose sucker gill net catch occurred differed from year to year (Table 14). Lower catches of longnose sucker in the discharge areas and Baie du Dore than in other sampling locations (Table 14) is consistent with the requirement of this species for cool, clear waters (Scott and Crossman, 1973). In addition, high spring abundance in the nearshore zone (Table 14) correlates well with the normal habit of spawning in streams or shallow areas of lakes during the spring (May and June) (Scott and Crossman, 1973).

White Sucker

This species normally spawns during the spring and early summer in streams or inshore areas of lakes (Scott and Crossman, 1973). The maximum gill net catch of white sucker generally occurred in May, June or July of each year (Table 14). In contrast to the data for longnose sucker, it is evident that white sucker were relatively abundant in the warm areas associated with the three thermal discharges, but were most abundant in Baie du Dore, especially in 1979 and 1980 (Table 14). This trend agrees with the fact that white sucker prefer the warmer waters of shallow bays (Scott and Crossman, 1973).

Brown Bullhead

Brown bullhead were captured in 1.2 m trap nets throughout the three-year study period. Overall catch was 209 in 1979, 208 in 1981 but only 44 in 1980 (Table 9). In each year the maximum number of brown bullhead were captured in Baie du Dore (July, 1979 and 1980 and May, 1981) (OHRD Report Nos 82-107-K, 82-182-K and 83-96-K). The preference of this species for warm shallow areas (such as the inshore area of Baie du Dore) is well-known (Scott and Crossman, 1973). Brown bullhead were not taken at Gunn Point in any year and were sparse at Sand Bay, Macpherson Bay and the three discharge locations. The catch at Scott Point in September, 1979 (9.3 fish per trap net) was the largest catch made outside of the Baie du Dore area where the maximum catch was 31.5 fish per trap net (July, 1979) (OHRD Report No 82-107-K). The thermal discharge areas are probably not favourable habitats for brown bullhead since these are high current areas with low proportions of sand (see Section 4.1.2).

Rock Bass

Rock bass were unevenly distributed along the shoreline in the BNPD study area. Maximum catch in 1.2 m trap nets occurred at either Baie du Dore or Bruce GS 'A' discharge in each year (Table 13). The catch of rock bass at Bruce GS 'A' discharge was highest during August, 1979 (9.5 fish per trap net) and was

the greatest catch per unit effort recorded during the study (Table 13). Apart from Scott Point, Baie du Dore and Bruce GS 'A' discharge, rock bass catches were low at other sampling locations (maximum = 5.0 fish per trap net at BHWP discharge in August, 1980) (Table 13).

Rock bass spawning is known to occur in both Baie du Dore and Bruce GS 'A' discharge. During June and July, 1980 SCUBA divers observed 35 rock bass nests in Baie du Dore (OHRD Report No 82-182-K). The highest proportion of nests (25) were located in the southwestern region of the bay. Half of the total number of nests were found in June, when peak rock bass spawning occurs (Scott and Crossman, 1973). Large numbers of rock bass have previously been observed in the Bruce GS 'A' discharge area and three nests were identified in the discharge channel during 1978 (OHRD Report Nos 80-43-K and 80-45-K).

These records of rock bass spawning and relative abundance suggest that free movement of rock bass probably occurs between Baie du Dore and Bruce GS 'A' discharge during the spawning season. It is probable that a single rock bass population utilizes both areas to spawn. The occurrence of higher catches in Baie du Dore during 1981 than in 1980 or 1979 may be indicative of a trend towards greater recruitment and subsequent survival in the Baie du Dore area.

Bruce GS 'A' discharge may augment rock bass survival in Baie du Dore by providing a warm water refuge area when the water temperature in the bay declines below that required for spawning. For example, during 1979 when the water temperature recorded in August and September at Baie du Dore was considerably lower than that observed at Bruce GS 'A' discharge (OHRD Report No 82-107-K) high rock bass catches were noted in the Bruce GS 'A' discharge area. However, lower catches occurred during the same months at Bruce GS 'A' discharge in 1981 when the temperature differential between the two locations was often not as substantial as that in 1979 (Figure 5). Relatively high rock bass catches occurred in August and September, 1981 in Baie du Dore (Table 13).

Bruce GS 'A' discharge may also represent a winter refuge area for rock bass. Evidence for this possibility was found during the 1980/81 winter fish residency study, when over 1500 rock bass were captured in the Bruce GS 'A' discharge channel (OHRD Report No 81-308-K). A mark-recapture experiment conducted during the winter residency study resulted in a 99% rock bass recapture frequency in the discharge channel. Fall and winter rock bass densities were estimated by the Schumacher multiple census technique as 3 121 and 2 226 fish, respectively, and it was concluded that rock bass were discharge residents throughout the fall and winter of 1980/81 (OHRD Report No 81-308-K).

Smallmouth Bass

The overall catch of smallmouth bass (in trap nets) was highest in 1981 (85 fish) and lowest in 1980 (13 fish) (Table 9). Although the overall catch of smallmouth bass was <100 in each year the maximum catch per trap net in 1979 was made during September at Bruce GS 'A' discharge (CUE = 4.0), and the largest catch in 1981 occurred at Baie du Dore during August (CUE = 1.5) (OHRD Report Nos 82-107-K and 83-96-K). Therefore the trends in rock bass and smallmouth bass distributions were similar during the three-year study period.

The state of the summer thermal regime in Baie du Dore relative to that of the Bruce GS 'A' discharge area may be associated with the observed change in fish distribution. The results of a multi-year study (1963-1982) of the smallmouth bass population at Baie du Dore are important in this respect (Institute for Environmental Studies - Final Summary Report, 1983).

The study determined that the thermal plume caused only a partial warming of the outer bay, and did not influence major spawning and nursery areas located in the inner bay. For example, in 1979 an increasing gradient of temperature extended from the back of the inner bay to the mouth of the outer bay.

A direct biological effect of the discharge was that growth rates were increased for both plume resident juvenile smallmouth bass and for some juvenile bass which migrated from the bay to the discharge in late summer. Relative abundance of juvenile smallmouth bass was also increased. However, biological events within Baie du Dore were not affected by the thermal plume. One indirect effect of the thermal effluent was the increase in total length of smallmouth bass of a given age class resulting in fish reaching a catchable size at an earlier age. The original bay fishery for smallmouth bass has largely been changed to a discharge fishery (Institute for Environmental Studies - Final Summary Report, 1983).

Although the general trend is towards a larger discharge resident population of smallmouth bass, some adult fish of this species may return to Baie du Dore when there is a major decline in the temperature of the effluent water (eg, during upwellings recorded in August and September, 1981; see Figure 5).

During the 1980/81 winter fish residency study only 76 smallmouth bass were captured in the fall, suggesting that this species was not resident in the Bruce GS 'A' discharge during the winter (OHRD Report No 81-308-K). This result differed from that obtained for rock bass during the same study (see above). However, the vulnerability of smallmouth bass to passive fishing

gear (windermere traps and gill nets in the 1980/81 study) was probably reduced due to the tendency for this species to remain very inactive during the winter (Scott and Crossman, 1973).

Walleye, Channel Catfish and Round Whitefish

Overall gill net catches of these three species were lowest in 1979 and highest in 1981 (Table 9). There were significant differences ($P < 0.01$) in the distribution of walleye and channel catfish with respect to month, location and year of sampling, and of round whitefish with respect to month and year of sampling (Table 11). Year to year variation in the month associated with the maximum channel catfish catch was indicated by a significant ($P < 0.01$) month x year interaction (Table 11).

Walleye were collected in largest numbers during September and October of each year (OHRD Report Nos 82-107-K, 82-182-K and 83-96-K). They occurred most frequently in the Bruce GS 'A' discharge followed by Macpherson Bay and BHWP discharge. Maximum catch per gill net set occurred at Bruce GS 'A' discharge during September, 1980 (15.0) although a similar catch per unit effort (CUE) was recorded at the same location in July, 1981 (OHRD Report Nos 82-182-K and 83-96-K). The increased abundance of walleye in and near the discharge areas in the fall is peculiar since these fish normally spawn in early spring at temperatures between 6°C and 9°C (Scott and Crossman, 1973). It is possible that walleye are initially attracted to the elevated temperatures and high currents found in the discharge areas while migrating along the shoreline. Some researchers consider the recent appearance of walleye in the BNPD area to be related to the dispersion of a very large year class along the eastern shores of Lake Huron. They suggested that walleye catches should decline in future years as average size year classes are produced (I.E.S. - Annual Technical Report, 1982).

The largest gill net catches of channel catfish also occurred during September, 1980 (CUE = 31.0) and July, 1981 (CUE = 33.0) at the Bruce GS 'A' discharge (OHRD Report Nos 82-182-K and 83-96-K). It is noteworthy that the discharge temperature dropped sharply on both of these occasions (see Figure 5), possibly allowing channel catfish (and walleye) to enter the near-field discharge area. Although channel catfish were most numerous in the thermal plume area they were captured all along the shoreline, particularly during September, 1981. Channel catfish are probably attracted to the thermal plume because they spawn at temperatures ranging from 24 to 29°C and because they often move into fast-flowing water to feed (Scott and Crossman, 1973).

Round whitefish exhibited maximum abundance in gill nets during October (CUE = 18.0) at Sand Bay in 1981 (OHRD Report No 83-96-K). There was no apparent preference for a particular location in any sampling month or year. The increase in relative abundance of round whitefish during the three-year period may reflect natural changes in the density of this species along the eastern shore of Lake Huron since a similar trend of increasing overall catch (from 193 to 317) was observed during the same period in the Bruce GS 'B' study area just south of the BNPD sampling area (OHRD Report Nos 82-229-K, 82-205-K and 83-451-K).

All Species

The fish species which frequented the nearshore zone off BNPD demonstrated considerable temporal variability in occurrence. Four temporal distribution patterns were identified. The most common pattern was for maximum relative abundance to occur during spring or early summer corresponding to the period of peak spawning of several species (eg, yellow perch, alewife, minnows and suckers). Some species, such as walleye and channel catfish, were more numerous in late summer and early fall even though they normally spawn earlier in the year. Other species were relatively abundant throughout the spring, summer and early fall sampling periods (eg, rock bass and smallmouth bass) although their usual spawning period is during early summer. Fall-spawning species such as round whitefish generally showed highest abundance in the fall.

There was minimal spatial heterogeneity observed in the BNPD sampling area for fish species such as yellow perch, alewife, minnows and suckers. However, rock bass, smallmouth bass, channel catfish and walleye displayed spatial distribution patterns which were distinctly heterogeneous and which, for the latter two species, were significantly different from random. Rock bass and smallmouth bass were largely associated with Baie du Dore or Bruce GS 'A' discharge while walleye and channel catfish were predominantly captured in Bruce GS 'A' discharge. Preference for the thermal plume area by these species is probably related to thermal tolerance characteristics (EPRI, 1981).

Acoustic Fish Census

Fish densities were estimated acoustically in 1980 within a 13-transect grid extending from Scott Point in the north to Macpherson Bay in the south, with the inshore margin at approximately the 5 m depth contour (Figure 2). Day samples were collected monthly from May to October while night samples were obtained in May, June, July and September.

The relative distributions of fish echoes in spring (May and June) day samples were similar, with highest densities recorded in the area of Loscombe Bank and just inshore from the bank. Lowest mean densities were generally found along transects with the greatest mean depth (Table 15). The night sample collected in May was also characterized by relatively high numbers of fish echoes. In both day and night samples the fish echoes were closely associated with the bottom and usually occurred singly or in small clusters.

Mean fish densities observed in June, July and September day samples exceeded 1000 fish/ha and were greater than those found in the corresponding night samples (Table 15).

The distribution of day and night fish echoes was more heterogeneous during June, July and September. Large fish schools were most often indicated in the July day sample and were associated with the bottom in 10 to 15 m of water. Conversely in August and September day samples smaller fish schools contributed to the echo counts, and highest fish densities were found at moderate-to-shallow depth.

The October day sample also showed a patchy distribution of fish echoes. However, single echoes due to large fish occurring at intermediate depths (8 to 12 m) were more prevalent than earlier in the year. The mean fish density was 401 fish/ha in October.

Gill netting conducted in areas of apparent echo concentration produced very few fish during the day, likely a consequence of net avoidance in clear water. Alewife dominated the catch in May and August but lake chub and suckers were more prominent in June, July and September. However, in survey gill net fishing alewife were dominant inshore (3 m contour) in June (1980) at most locations sampled. Gizzard shad and round whitefish accounted for larger portions of the September and October catches. This result is consistent with the results of regular survey gill net fishing in 1980 (OHRD Report No 82-182-K).

B. Ichthyoplankton

Species Composition

Substantially more larval fish representing a larger number of taxa were collected in 1981 than in 1979 (Table 16). This result was probably due to the addition of 1 m contour sampling locations in 1981. Increased larval smelt *(Osmerus mordax)* and alewife catches were primarily responsible for the higher 1981 larval fish catch. The ratio of alewife to smelt larvae captured was approximately 2:1 in 1981, whereas roughly even numbers of these species were collected in 1979 (Table 16).

TABLE 15

SUMMARY OF ACOUSTICALLY ESTIMATED FISH DENSITIES
AT BNPD - 1980

Date	South Transect* 1	2	3	4	5	6	7	8	9	10	11	12	North 13	Overall Mean
Day														
May 21	454.8	655.4	858.6	1323.4	2899.8	2329.1	2326.0	2292.5	189.6	1411.5	1482.9	7422.8	4541.5	2299.5
June 17	179.1	312.6	368.7	894.4	2196.4	2311.1	1009.9	915.7	1024.9	699.0	669.0	706.9	983.5	1020.9
July 31	243.7	1761.4	683.1	738.8	1233.9	1494.9	1061.3	1239.8	850.4	1066.6	1101.7	1281.7	851.2	1046.8
August 20	161.4	86.3	403.8	792.8	1003.6	965.7	1193.9	893.1	781.8	596.5	657.6	1052.7	575.8	705.0
September 24	235.9	480.0	697.8	964.9	1203.4	1133.6	1342.9	1483.6	2331.8	805.5	493.4	933.6	1264.7	1028.5
October 26	120.3	151.6	277.2	409.7	435.8	280.3	418.6	724.1	348.8	465.1	264.4	372.0	946.0	401.1
Night														
May 21	647.4	924.7	613.6	2092.6	2531.0	1752.9	3434.7	2463.2	2947.0	1942.7	1963.1	3743.0	5535.6	2430.1
June 18	184.3	237.8	368.2	510.5	971.7	1154.3	951.6	1343.7	818.7	734.3	514.9	380.8	754.4	686.6
July 29	124.7	154.8	239.6	552.7	541.2	419.5	222.2	381.3	268.5	259.0	285.1	1100.4	103.1	357.9
September 24	190.3	151.3	230.3	779.2	455.5	577.7	905.8	313.9	772.4	562.9	582.0	988.1	1007.4	578.2
Transect Average	254.2	491.6	574.1	906.0	1347.2	1242.0	1386.7	1205.1	1204.0	854.3	801.4	1798.2	1656.3	
Mean Depth (m)	14.1	13.2	9.9	7.6	6.6	7.1	7.1	7.2	76.	9.1	9.4	7.1	6.2	

*See Figure 2 for transect orientation

TABLE 16

TAXONOMIC COMPOSITION OF LARVAL FISH
COLLECTED IN SURFACE LAKE TOWS AT BNPD IN 1979 AND 1981

Taxon	1979		1981	
	Number	Per Cent	Number	Per Cent
Alewife (*Alosa pseudoharengus*)	486	46.4	2679	45.4
Smelt (*Osmerus mordax*)	506	48.3	1512	25.6
Carp (*Cyprinus carpio*)	-	-	1072	18.2
Cyprinidae	13	1.2	289	4.9
Johnny darter (*Etheostoma nigrum*)	-	-	104	1.8
Burbot (*Lota lota*)	7	0.7	82	1.4
Gizzard shad (*Dorosoma cepedianum*)	7	0.7	23	0.4
Yellow perch (*Perca flavescens*)	7	0.7	23	0.4
Trout perch (*Percopsis omiscomaycus*)	-	-	16	0.3
Deepwater Sculpin (*Myoxocephalus quadricornis*)	6	0.6	11	0.2
Coregonidae	13	1.2	-	-
Cisco (*Coregonus artedii*)	-	-	11	0.2
Mottled sculpin (*Cottus bairdi*)	-	-	7	0.1
Slimy sculpin (*Cottus cognatus*)	-	-	6	0.1
White sucker (*Catostomus commersoni*)	1	0.1	5	0.1
Darter (*Percina* sp)	5	0.5	-	-
Percidae	1	0.1	4	0.1
Pumpkinseed (*Lepomis gibbosus*)	1	0.1	2	<0.1
Logperch (*Percina caprodes*)	-	-	2	<0.1
Cottidae	-	-	1	<0.1
Gasterosteidae	-	-	1	<0.1
Brown bullhead (*Ictalurus nebulosus*)	-	-	1	<0.1
Golden shiner (*Notemigonus crysoleucas*)	-	-	1	<0.1
Unidentified	2	0.2	-	-
(Number of taxa)	1048 (12)		5896 (21)	

Species which occurred in 1981 but were not taken in 1979 included carp *(Cyprinus carpio)* johnny darter *(Etheostoma nigrum)*, gizzard shad, trout-perch *(Percopsis omiscomaycus)* and cisco *(Coregonus artedii)*. It is possible that johnny darter and cisco were among the larval fish collected in 1979 since several fish could not be identified below the taxonomic level of family; two larval fish could not be identified at all in 1979 (Table 16).

Temporal and Spatial Distribution

Alewife

Alewife larvae occurred in inshore surface waters from late June through late August in both sampling years. Maximum larval alewife densities were recorded during early July in 1981 and early August in 1979, but were higher in 1981 than in 1979 (Table 17). Catches along the 1 m contour contributed substantially to the higher 1981 densities (Table 17).

Alewife larvae were on average longer in 1981 than in 1979, when fish from corresponding sampling periods of each year are compared (Table 18). This finding supports the suggestion that adult alewife may have migrated inshore to spawn a few weeks earlier than expected in 1981, possibly due to the influence of warmer spring (May) lake temperatures in that year. Highest densities of larval alewife were recorded at the 1 m contour of Bruce GS 'A' discharge, Bruce GS 'A' intake and Douglas Point GS discharge during 1981 (Table 17).

There was some evidence for the northward dispersion of alewife larvae during August 1979 and during July 1981 (OHRD Report Nos 82-107-K and 83-96-K). Sequential changes in larval alewife distribution along the shoreline may indicate that inshore alewife spawning first occurs near the thermal plume influenced areas and subsequently takes place at other inshore locations. In addition, longshore currents directed towards the north may shift the concentrations of alewife larvae northward along the BNPD shoreline.

Alewife larvae captured in Lake Michigan were more abundant inshore ($\leq$6 m) or close to the bottom during upwelling periods, and occurred in lower absolute densities than in the absence of upwelling (Heufelder et al 1982). The present data are insufficient to show such trends within the BNPD area of Lake Huron.

TABLE 17

TEMPORAL AND SPATIAL DISTRIBUTION OF LARVAL SMELT AND ALEWIFE AT BNPD DURING 1979 AND 1981 (MEAN NO LARVAE/1000 m^3)

TEMPORAL

		May		June		July		August	
	(Year)	Week 2	Week 4	Week 2	Week 4	Week 2	Week 4	Week 1	Week 3
Smelt	(1979)	165.0	153.0	38.0	3.0	2.0	0.0	0.0	0.0
	(1981)	639.6	12.9	68.3	2.4	2.1	3.3	0.0	3.8
Alewife	(1979)	0.0	0.0	0.0	2.0	63.0	0.0	210.0	74.0
	(1981)	0.0	0.0	0.0	58.0	1034.0	130.0	0.0	53.0

SPATIAL

	Depth Contour	(Year)	Scott Point	Baie du Dore*			Bruce GS 'A' Discharge	Bruce GS 'A' Intake	BHWP Discharge	Douglas Point GS Discharge
Smelt	1 m	(1981)	5.7	7.1	0.0	2.8	101.4	65.7	694.3	281.4
	3 m	(1979)	6.4	15.0	129.2	11.4	250.8	60.0	50.0	37.1
		(1981)	301.4	27.1	1.4	7.1	174.3	71.4	62.8	157.1
	7 m	(1979)	42.1				25.4	75.0	105.7	10.0
		(1981)	72.8				78.5	48.5	104.3	142.8
	12 m	(1979)	17.1				60.0	83.0	4.6	16.4
Alewife	1 m	(1981)	38.5	238.5	160.0	95.7	904.3	885.7	651.4	45.7
	3 m	(1979)	94.3	65.0	58.5	78.6	33.8	30.9	23.1	187.1
		(1981)	48.5	171.4	95.7	78.5	74.3	58.5	540.0	545.7
	7 m	(1979)	80.7				6.9	15.0	54.3	65.0
		(1981)	94.3				21.4	42.8	45.7	27.1
	12 m	(1979)	24.3				10.7	18.5	26.2	173.6

* three sampling points in Baie du Dore

TABLE 18

COMPARISON OF MEAN TOTAL LENGTHS (mm) OF LARVAL SMELT AND ALEWIFE AT BNPD IN 1979 and 1981

		April	May		June		July		August	
	(Year)	Week 4	Week 2	Week 4	Week 2	Week 4	Week 2	Week 4	Week 1	Week 3
Smelt	(1979)	-	5.6 (3.0-7.0)*	6.1 (5.0-9.0)	10.2 (6.0-15.0)	-	-	-	-	-
	(1981)	-	6.2 (5.5-7.0)	6.0 (5.5-7.0)	6.8 (5.5-11.0)	7.4 (6.5-9.0)	21.0 (18.5-24.0)	26.9 (17.0-35.0)	-	37.4 (34.0-43.0)
Alewife	(1979)	-	-	-	-	-	4.3 (3.0-7.5)	-	12.4 (6.0-25.0)	16.3 (8.0-25.0)
	(1981)	-	-	-	-	5.0 (4.5-10.0)	5.3 (4.5-18.0)	16.0 (5.0-30.0)	-	23.0 (9.0-40.0)

* Length range in parentheses.

Smelt

Smelt larvae occurred throughout the BNPD nearshore zone during 1979 and 1981. They were taken in surface plankton tows from early May through late August in 1981, and from early May until early July in 1979 (Table 17). Distribution in surface waters did not vary greatly with increasing distance from shore except for BHWP discharge and Scott Point locations, where substantially higher larval smelt densities occurred at the 1 m and 3 m contour sampling points, respectively (Table 17).

Maximum densities of smelt larvae were recorded during May in both years. In 1981 low densities were still recorded in surface waters several weeks beyond the time when no smelt larvae were caught in surface waters in 1979 (Table 17). Smelt observed later in the year in 1981 were mainly large larvae or juveniles ranging in total length from 17.0 to 43.0 mm (Table 18), and occurred more often at the 3 m and 7 m contours of the Bruce GS 'A' discharge, Bruce GS 'A' intake, and BHWP discharge transects. The occurrence of large smelt larvae (and small juveniles) in surface inshore waters near BNPD during July and August is unusual and may be related to upwelling activity, but more sampling would be required to demonstrate such a phenomenon.

Other Larvae

Among the more abundant fish larvae (excluding smelt and alewife larvae) two principal distribution patterns were observed in 1981 (OHRD Report No 83-96-K). Some larvae, such as cisco larvae, were captured largely at 3 m or 7 m contour locations, suggesting that the larvae are not produced close inshore or that they move offshore soon after hatching. Burbot and deepwater sculpin larvae were mainly taken in forebay sets and thus were probably generated in deep water, consistent with the normal spawning behaviour of these species (Scott and Crossman, 1973).

Several other fish larvae, including cyprinid, carp and gizzard shad larvae were recorded in highest densities inshore. Cyprinid larvae were most abundant at the 1 m contour of Baie du Dore and Scott Point locations during July, 1981. Carp larvae were concentrated at the 3 m and 7 m contours of the Bruce GS 'A' discharge transect in June, 1981 and at the 1 m contour of the Bruce GS 'A' intake and discharge transects in July, 1981 (OHRD Report No 83-96-K). These fish were probably spawned in the Bruce GS 'A' discharge area or the southwestern portion of Baie du Dore. Gizzard shad larvae were captured close inshore (1 m contour), mainly within Baie du Dore during late June and late July, 1981. This distribution suggests that gizzard shad

selectively spawned in shallow Baie du Dore waters in 1981, and is consistent with the occurrence of adult gizzard shad in the bay (as previously noted).

Apart from carp and alewife larvae, no pronounced occurrence of fish larvae along discharge transects was noted. Thus noted larval fish species appeared to be unaffected by the presence of the Bruce GS 'A', BHWP and Douglas Point GS thermal discharges.

C. Fish Age and Growth

Age Structure

The age structures of longnose sucker, white sucker, rock bass and yellow perch were examined both in 1979 and 1981. Age distribution data were obtained for other fish species in either 1979 or 1981 only, and are not presented in this report. Fewer fish of each species were aged in 1981 than in 1979.

Among longnose sucker aged in 1979 fish of the 1970 year class were most abundant while fish in the 1970 and 1971 year classes were slightly more numerous in the 1981 sample (Table 19). There was no indication of a shift in age distribution between 1979 and 1981, based on the available data.

For white sucker the dominant year classes were 1971 through 1974 (ages 5 to 8) in the 1979 sample, and year classes 1971 to 1973 and 1975 (ages 6 and 8-10) in the 1981 sample (Table 19). The small 1981 sample size likely accounts for the absence of the 1974 year class, which was relatively large in 1979. Although fewer white sucker age groups were represented in 1981 no evidence of a change in age distribution was observable.

With respect to yellow perch, age 5 fish were most abundant in both the 1979 and 1981 samples. The limited 1981 sample size precluded direct comparison of other age groups. Consequently no inference is possible concerning change in yellow perch age structure over the 1979-1981 period.

A noticeable change in the age structure of rock bass occurred between 1979 and 1981, despite the availability of small sample sizes in both years. The observed trend appears to be a downward shift in the relative abundance of various age classes. Whereas fish aged 3 and 4 were prominant in the 1979 sample fish aged 2 dominated the 1981 sample (Table 19). The 1977 or 1978 (but not 1979) year class would presumably have been most abundant in the 1981 sample in the absence of a shift in age distribution.

TABLE 19

COMPARISON OF 1979 AND 1981 AGE STRUCTURES
OF FOUR FISH SPECIES COLLECTED AT BNPD

Fish Species	Survey Year	Age in Years																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Longnose Sucker	1979 (n=110)				9	5	6	10	9	19	9	12	8	6	6	3	5	1	1	0	1
	[Year Class]				[1975,	74,	73,	72,	71,	70,	69,	68,	67,	66,	65,	64,	63,	62,	61,	60,	59]
	1981 (n=16)					1	1	0	0	2	1	3	2	2	0	2					
	[Year Class]					[1976,	75,	74,	73,	72,	71,	70,	69,	68,	67,	66]					
White Sucker	1979 (n=91)		2	0	3	13	11	13	14	9	8	8	7	1	2						
	[Year Class]		[1977,	76,	75,	74,	73,	72,	71,	70,	69	68	67	66	65]						
	1981 (n=20)						4	0	4	5	4	0	2	0	0	1					
	[Year Class]						[1975,	74,	73,	72,	71,	70,	69,	68,	67,	66]					
Rock Bass	1979 (n=24)		2	7	7	5	3														
	[Year Class]		[1977,	76,	75,	74,	73,]														
	1981 (n=15)	1	6	4	3	1															
	[Year Class]	[1980,	79,	78,	77,	76]															
Yellow Perch	1979 (n=80)		6	8	11	15	8	14	12	5	1										
	[Year Class]		[1977,	76,	75,	74,	73,	72,	71,	70,	69]										
	1981 (n=11)		2	1	1	4	2	1													
	[Year Class]		[1979,	78,	77,	76,	75,	74]													

A similar downward shift in the relative abundance of dominant smallmouth bass age classes was observed in the BNPD area between 1976-1980 (IES, Final Summary Report, 1983). The observed change in rock bass age structure could have been caused by (i) increased capture of older rock bass by anglers (increased angling pressure in the Bruce GS 'A' discharge area) or (ii) an effect of the thermal plume itself (eg a growth change) or (iii) a combination of the above two factors.

Fish Growth

Analysis of fish growth was performed for rock bass only, since anomalies were found in the spatial distribution and age structure of this species.

Growth of rock bass was compared for the years 1977, 1978, 1979 and 1981 (Figure 10). Rock bass showed similar growth increments during 1977 and 1978, when Bruce GS 'A' was operating well below peak power output (OHRD Report Nos 78-395-K and 80-43-K). An increase in growth rate is apparent for rock bass captured in 1979, particularly for fish 3 to 6 years old. Rock bass were primarily captured in the Bruce GS 'A' discharge during 1979.

Rock bass obtained in 1981 displayed a growth pattern similar to fish taken in 1977 and 1978 except for age 5 fish (n = 1), which had a growth increase closer to fish captured in 1979. It is important to note that all rock bass aged 1 to 4 in the 1981 sample were captured at Baie du Dore while the single age 5 fish was caught in the Bruce GS 'A' discharge.

The difference in capture site of rock bass taken in 1979 and 1981 probably accounted for the observed difference in growth rate between the two years. However, the assumption must be made that the greater portion of new growth (increase in length) occurred during fish residency at the principal capture location (Bruce GS 'A' discharge in 1979 and Baie du Dore in 1981). This assumption is reasonable since rock bass catches were consistently high over the 1979 and 1981 growing seasons (May-September) at Bruce GS 'A' discharge and Baie du Dore, respectively (Table 13).

Rock bass growth is clearly variable from year to year in the BNPD area. The degree of natural lake warming during the spring and summer is likely to strongly influence the movement of rock bass between Bruce GS 'A' discharge and Baie du Dore, and consequently have a direct effect on the growth of rock bass in the BNPD nearshore zone. Rock bass which reside in the Bruce GS 'A' discharge area during late summer and fall may grow faster than those which remain in Baie du Dore. This effect has been demonstrated for smallmouth bass (IES - Final Summary Report, 1983).

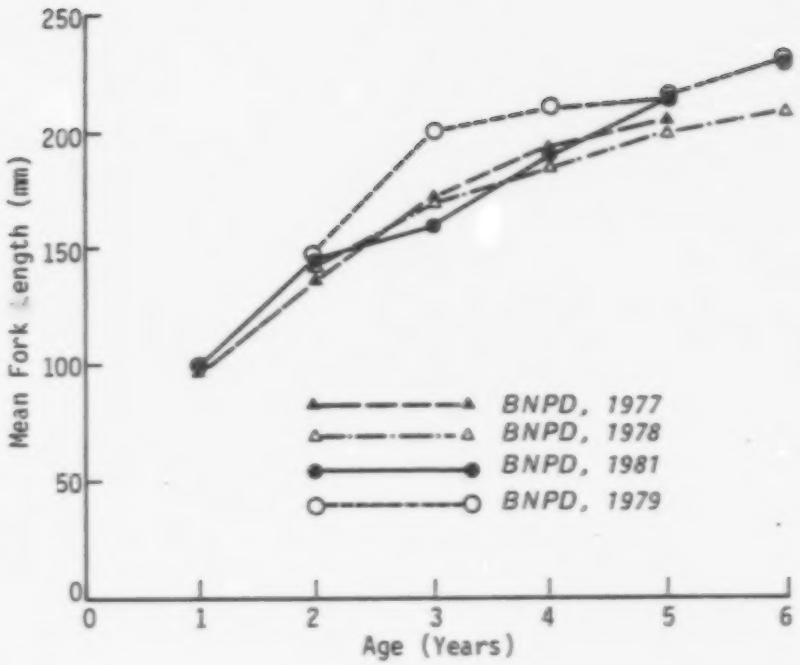

FIGURE 10

COMPARISON OF GROWTH OF ROCK BASS AT BNPD DURING 1977, 1978, 1979 AND 1981

D. Fish Stomach Contents

Five fish species (longnose sucker, white sucker, rock bass, yellow perch and brown bullhead) were examined for stomach contents both in 1979 and 1981. The per cent frequency of occurrence and per cent biomass of food items found in the stomachs of these species is presented in Table 20.

Brown bullhead fed principally on Decapoda (crayfish) in 1979 but also consumed other benthic macroinvertebrates such as Diptera and Gastropoda. The single brown bullhead examined in 1981 also had crayfish in its stomach. A larger sample size would probably have yielded a result similar to that obtained in 1979.

During 1979, longnose sucker and white sucker showed a high degree of similarity in the proportions and kinds of food items contained in their stomachs (Table 20). Both species consumed a variety of aquatic insects as well as Amphipoda, Isopoda and Acarina. A considerable proportion (33% by weight) of fish occurred in the stomach of one longnose sucker in 1979, but was due to the presence of a single alewife. A large amount of the stomach contents of both sucker species was comprised of digested, detrital or unidentified material in 1979.

The composition of food items in the stomachs of both longnose sucker and white sucker in 1981 differed somewhat from that found in 1979. Unidentifiable or miscellaneous material comprised almost 70% of the total biomass of stomach contents of longnose sucker in 1981 (Table 20). The only identifiable organisms were Acarina (2% by weight) and Diptera (29% by weight), which occurred more frequently in the stomachs of longnose sucker sampled in 1981. However the sample size was greater in 1979(73) than in 1981(10) (Table 20).

For white sucker the frequency of occurrence of Gastropoda, Amphipoda and some aquatic insects (Ephemeroptera, Diptera and Trichoptera) appeared to increase in the stomachs examined, but this result is probably also due to the difference in sample sizes between the two sampling years (Table 20). However, the proportion by weight of Gastropoda consumed increased from 6% in 1979 to 55% in 1981, suggesting that a true increase in the contribution of this group of organisms to the diet of white sucker occurred in 1981. The proportion (by weight) of unidentifiable material in the stomachs of white sucker decreased from 68% in 1979 to 33% in 1981.

Rock bass consumed 67% (by weight) fish and 27% (by weight) crayfish in 1979. These proportions were reversed in 1981 with

TABLE 20

PERCENT FREQUENCY OF OCCURRENCE AND PERCENT BIOMASS
OF FOOD ITEMS IN STOMACHS OF FIVE FISH SPECIES CAPTURED AT BNPD IN 1979 AND 1981

Food Item by Major Taxon		Longnose Sucker *N=73 and 10				White Sucker *N=50 and 15				Rock Bass *N=10 and 9				Yellow Perch *N=50 and 10				Brown Bullhead *N=23 and 1			
		% Occurrence		% Biomass		% Occurrence		% Biomass		% Occurrence		% Biomass		% Occurrence		% Biomass		% Occurrence		% Biomass	
Class	Order	79	81	79	81	79	81	79	81	79	81	79	81	79	81	79	81	79	81	79	81
Oligochaeta		0.00	0.00	0.00	0.00	1.80	0.00	0.10	0.00	0.00	0.00	0.00	0.00	1.50	0.00	0.10	0.00	0.00	0.00	0.00	0.00
Arachnida	Acarina	10.00	10.00	0.50	2.22	10.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	10.00	0.00	0.30	0.00	5.00	0.00	0.05	0.00
Crustacea		--	--	3.60	0.00	--	--	1.60	2.26	--	--	27.10	94.71	--	--	11.50	98.17	--	--	47.40	100.00
	Amphipoda	9.00	0.00	1.50	0.00	6.00	53.33	1.00	1.63	0.00	0.00	0.00	0.00	15.00	0.00	1.00	0.00	26.00	0.00	3.20	0.00
	Decapoda	2.00	0.00	1.60	0.00	0.00	13.33	0.00	0.48	40.00	67.00	27.10	94.71	31.00	90.00	12.00	98.17	35.00	100.00	44.00	100.00
	Isopoda	1.00	0.00	0.50	0.00	1.00	6.70	0.30	0.15	0.00	0.00	0.00	0.00	2.00	0.00	0.50	0.00	4.50	0.00	0.10	0.00
	Ostracoda	0.00	0.00	0.00	0.00	1.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	0.00	0.10	0.00
Insecta		--	--	2.90	29.15	--	--	8.50	7.75	--	--	5.70	0.31	--	--	4.20	0.80	--	--	4.70	0.00
	Ephemeroptera	7.00	0.00	0.50	0.00	10.00	33.33	4.00	0.90	10.00	6.70	5.70	0.31	4.00	0.00	0.50	0.00	13.00	0.00	0.20	0.00
	Coleoptera	1.00	0.00	0.50	0.00	1.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	4.00	0.00	0.50	0.00	5.00	0.00	0.40	0.00
	Diptera	22.00	60.00	1.50	29.15	26.00	60.00	2.50	5.92	0.00	0.00	0.00	0.00	30.00	0.00	3.00	0.00	31.00	0.00	2.00	0.00
	Lepidoptera	0.00	0.00	0.00	0.00	1.50	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	0.00	0.10	0.00
	Trichoptera	2.00	0.00	0.40	0.00	12.00	13.33	1.00	0.31	0.00	0.00	0.00	0.00	12.00	0.00	0.20	0.00	21.00	0.00	2.00	0.00
	Hemiptera	0.00	0.00	0.00	0.00	0.00	13.33	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gastropoda		9.00	0.00	2.90	0.00	14.00	67.00	5.90	54.73	0.00	0.00	0.00	0.00	12.00	0.00	5.20	0.00	31.00	0.00	12.00	0.00
Pelecypoda		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	0.00	0.50	0.00
Fish or Fish Remains		--	--	33.10	0.00	--	--	15.70	0.00	--	--	67.20	4.96	--	--	33.20	1.03	--	--	0.00	0.00
Miscellaneous (Algae, Detritus) or Unidentified		--	--	57.30	68.64	--	--	67.90	33.32	--	--	0.00	0.00	--	--	21.30	0.00	--	--	36.60	0.00

* Fish sample sizes in 1979 and 1981, respectively
-- no value obtainable

the stomach contents of rock bass containing almost exclusively crayfish (95% by weight). In both years aquatic insects contributed minimally to the food items ingested by rock bass.

A substantial increase in both frequency of occurrence and the per cent biomass of crayfish was observed in the stomachs of yellow perch in 1981. Fish or fish remains accounted for a smaller proportion of the food items consumed in 1981 compared to 1979.

In general, the fish species examined fall within one of three categories with respect to the composition of stomach contents. Longnose sucker and white sucker were representative of bottom-feeding species that consume a variety of benthic macroinvertebrates, with no clear preference for a particular group of organisms being observed. However, white sucker appeared to feed on a greater range of organisms than the longnose sucker. The small sample sizes of longnose sucker and white sucker examined in 1981 partially accounted for the differences in stomach contents of these species observed between 1979 and 1981, although white sucker consumed more gastropods in 1981 than in 1979.

The second category is that of bottom-feeding species which consume a large proportion of crayfish and a small amount of aquatic insects. Brown bullhead was the only species which exhibited this diet composition, based on the 1979 data.

Yellow perch and rock bass were examples of fish species containing substantial proportions of either fish (or fish remains) or crayfish in their stomachs. The greater proportion of crayfish consumed by rock bass in 1981 is not unusual since the same result was noted for rock bass examined in 1976, 1977 and 1978 in the BNPD nearshore area (OHRD Report Nos 77-167-K, 78-395-K, and 80-43-K). The variation in composition of stomach contents of yellow perch between sampling years was typical of the feeding habits of this species (Scott and Crossman, 1973).

4.2.7 Nesting Gulls

A mixed colony of ring-billed gulls *(Larus delawarensis)* and herring gulls *(L. argentatus)* was present on the land fill area between Bruce GS 'A' discharge and Macpherson Bay during the three year study. Substrate on the colony consisted of loose rock and compacted fill surrounded by a gravel beach. A chain link fence split the main colony into two sections.

A comparison of estimates of the numbers of nests at BNPD in 1979, 1980 and 1981 is presented in Table 21. Although the number of nests counted in 1980 and 1981 fell within the range

TABLE 21

NUMBER OF GULL NESTS AT BNPD, 1979-1981

	1979		1980		1981	
	Ring-Billed[1]	Herring	Ring-Billed[2]	Herring[2]	Ring-Billed[2]	Herring[2]
Inside Fence			4548	120	3761	87
Outside Fence		141[2]	1263	165	912	173
Total	4000-6000	200-300[1]	5811	285	4673	260

[1] Visual estimate
[2] Nest Count

of the visual estimate made in 1979 (OHRD Report No C79-246-K) there appeared to be about a 19% drop in the number of nests from 1980 (5811 ring-billed gull, 285 herring gull) to 1981 (4673 ring-billed gull and 260 herring gull). The reduction in the number of nests appeared to be from the periphery of the colony. Gulls nesting at the periphery of a colony tend to be younger (Haymes and Blokpoel, 1980) and may be more prone to move to another colony to breed.

5.0 SUMMARY

Bruce GS 'A' increased its annual average electrical output from 77% to 91% of peak power capacity between 1979 and 1981. During this period the temperature differential across the station was variable but appeared to be relatively stable in 1981. The highest mean temperature differential (between discharge and intake) observed at any generating station was 11.2C° and occurred at Douglas Point GS during November/December, 1980. Discharge flows at BHWP and Douglas Point GS showed little variablity over the study period but the discharge flow at Bruce GS 'A' was more variable, especially during 1981.

The substrate at BNPD was quite heterogeneous. Some areas, such as Scott Point and Bruce GS 'A' discharge, were mainly composed of boulder-cobble materials. Locations such as Bruce GS 'A' intake and the inshore area of Macpherson Bay were exposed bedrock overlain by pockets of pebble-gravel substrate. The inner portion of Baie du Dore had a sand-silt bottom but pebble-gravel areas predominated near the mouth of the bay.

Sedimentation rates were generally highest inshore, and during the May to August sampling period were greater in 1981 than in 1979. This result was due mainly to the accumulation of material along the Douglas Point GS discharge and Gunn Point transects, and was possibly related to the resuspension of particulate matter during construction activities at the Bruce GS 'B' intake site in 1981. Greater resuspension of particulate matter by high fall winds likely caused the fall (August-November) sedimentation rates to exceed the spring/summer (May-August) rates in 1979.

The area influenced by Bruce GS 'A' discharge appeared to be more thermally stable during winter and spring than other areas sampled, particularly during 1981. Water temperatures at Baie du Dore were characteristically intermediate between those of Bruce GS 'A' discharge and Bruce GS 'A' intake locations. Frequent major upwellings, represented by large rapid drops in temperature lasting at least 24 to 48 h, were evident in the nearshore region in all three years. Vertical stratification at monitoring sites other than Bruce GS 'A' discharge began in the

spring (June) and lasted until fall (September). However the Bruce GS 'A' thermal plume resulted in the creation of vertical thermal gradients which persisted until the end of October.

Variability in water clarity was mainly seasonal, being greater during the summer (August) than the spring and fall. Water clarity increased slightly with depth at most locations sampled in October 1979. Longshore differences in water transparency were noted, with lowest Secchi disc readings (= low water clarity) recorded at the more northerly locations (Sand Bay and Scott Point) and higher readings obtained at the southernmost transects(Douglas Point GS, BHWP and Gunn Point). Secchi disc values at Bruce GS 'A' discharge were intermediate between those observed at the northern and southern parts of the study area.

Water quality conditions during the 1979-1981 period generally reflected the oligotrophic state of Lake Huron. Normal seasonal changes in the levels of nutrient parameters (phosphorous, nitrogen and silica) were observed. Most parameters showed little seasonal or annual variation and did not show changes indicative of a thermal plume influence.

Attached algae exhibited a rather patchy distribution along the shoreline, with high cover occurring mainly at Bruce GS 'A' discharge and in areas of high cottage density (between Sand Bay and Scott Point). This distribution pattern was likely related to the availability of suitable stable substrate (large sized particles) for algal attachment, high water temperatures and currents (Bruce GS 'A' discharge) and high nutrient input (cottage areas). The species composition of attached algae shifted in 1981 with the appearance of the genera *Bulbochaete* and *Calothrix*. Considerable variability was observed in the distribution of individual algal species. No consistent trend was found in the attached algae biomass data, but the maximum ash free dry weight for a single sample (300.16 gm/m^2) occurred at the Bruce GS 'A' discharge in June, 1979.

A variety of sedges, grasses, shrubs and flowering herbs were found in the Baie du Dore wet meadow zone, while emergent rushes, bulrushes and spike rushes dominated the shallow marsh zone. Macrophyte biomass was substantially higher at the deeper sampling points and was maximal on the August 25 sampling occasion. The Baie du Dore marsh area is considered low to moderately productive compared to other rush and sedge dominated wetlands.

Diatoms maintained the highest biomass among phytoplankton groups within the study area. Green algae and blue-green algae gained prominence in August and October, respectively, of 1979 and 1980. Phytoplankton biomass was highest in the spring (May

or June) when the diatom genera *Rhizosolenia* and *Tabellaria* were the most abundant taxa. No consistent spatial trends in phytoplankton distribution were found during the study period. However, in June, 1979 phytoplankton densities were highest in the inshore area of Baie du Dore.

Species composition of the dominant rotifer zooplankton changed between 1979 and 1980. *Synchaeta* spp was the most numerous group in 1979 while several different genera appeared to dominate sequentially throughout the 1980 sampling period. Calanoid copepods dominated the crustacean zooplankton in the BNPD study area in both 1979 and 1980. The longshore distribution patterns of the main rotifer and crustacean zooplankton were not consistent either monthly or yearly. In terms of vertical distribution the main zooplankton taxa had greater abundances in the lower portion of the water column during July and August, 1979 and 1980, as indicated by sampling at the 12 m contour of the Scott Point transect. This result is consistent with the finding that zooplankton were often abundant in the Bruce GS 'A' forebay into which condenser cooling water is drawn from an 11 m depth.

However, relocation of zooplankton from bottom to surface waters (via the Bruce GS 'A' condenser cooling system) was not reflected in the surface spatial distribution of zooplankton.

In rock cage samples, the proportion of naidid worms in the total collection increased from 19% to 30%, while that of dipterans dropped from 33% to 20% between 1979 and 1981. This increased contribution of naidids to the rock cage collections was due mainly to the occurrence of a high concentration of *Nais pardalis* at the 3 m contour of the Bruce GS 'A' discharge transect in July, 1981. The number of benthic organisms in rock cages was greatest in the shallow waters of Baie du Dore in both sampling years. Amphipods, the dipteran *Cladopelma*, and the trichopteran *Cheumatopsyche* were also found in high local concentrations in 1981, reflecting the tendency of rock cages to facilitate the formation of isolated colonies of benthic organisms.

In vacuum dome collections the density of dipterans (especially chironomids) increased while that of naidids remained unchanged between 1979 and 1981. Naidid worms were most abundant in shallow water (3 m contour) at the discharge locations, particularly Bruce GS 'A' discharge. The concentration of these worms in Baie du Dore and thermal discharge locations may have been promoted by thermal discharge heat enrichment. Chironomids occurred more often at deeper sampling points (7 m and 12 m contours) and along the northernmost transects (Scott Point to Sand Bay). Depth, substrate type and temperature were found to

be the most important variables influencing the distribution of the main benthic organisms in 1979.

Alewife was generally the most abundant larval and adult fish species occurring within the BNPD nearshore area. Gill net catches of adult alewife reflected a normal seasonal abundance pattern, but did not vary significantly among sampling transects or years. Temporal (monthly) variability was evident for most of the fish species collected, and highest inshore abundance often corresponded to the well-known spawning migrations of many species. However, adult rock bass, smallmouth bass, walleye and channel catfish were relatively abundant in the BNPD area throughout summer and early fall, although these species usually spawn earlier in the year. Rock bass and smallmouth bass were most abundant at Bruce GS 'A' discharge in 1979 and at Baie du Dore in 1981. Walleye and channel catfish were primarily taken in the Bruce GS 'A' discharge suggesting an affinity for that location. No pronounced occurrence of fish larvae along discharge transects was noted, except for alewife and carp larvae, some of which were probably produced within or near to the Bruce GS 'A' discharge. Gizzard shad larvae occurred mainly at the 1 m contour of Baie du Dore during the summer of 1981. The highest densities of larval fish (particularly alewife and smelt larvae) occurred along the 1 m and 3 m contours within the BNPD study area.

A downward shift in the predominant age classes of rock bass, from 3 and 4 year-old fish to 2 year-old fish, was observed between 1979 and 1981, and may be attributable to a combination of increased angler pressure and plume-induced growth changes.

White sucker and longnose sucker consumed a variety of crustaceans and aquatic insects during both sampling years but the diet of yellow perch and rock bass was more restricted, with fish and crayfish being the principal diet components. Brown bullhead also fed heavily on crayfish.

The number of nesting gulls decreased by 19% in 1981, possibly as a result of gulls moving to other colonies.

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